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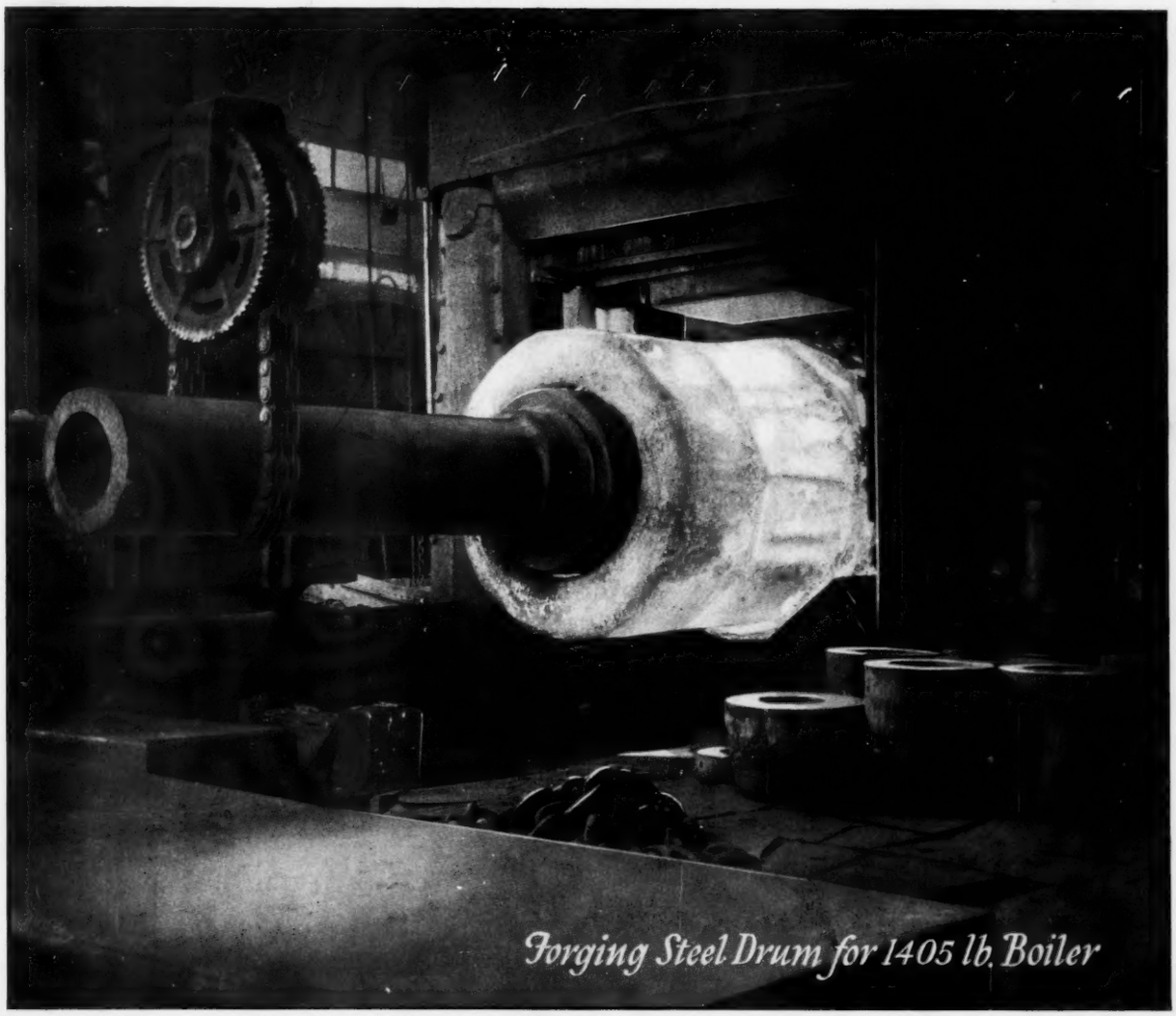


Forging Steel Drum for 1405 lb. Boiler

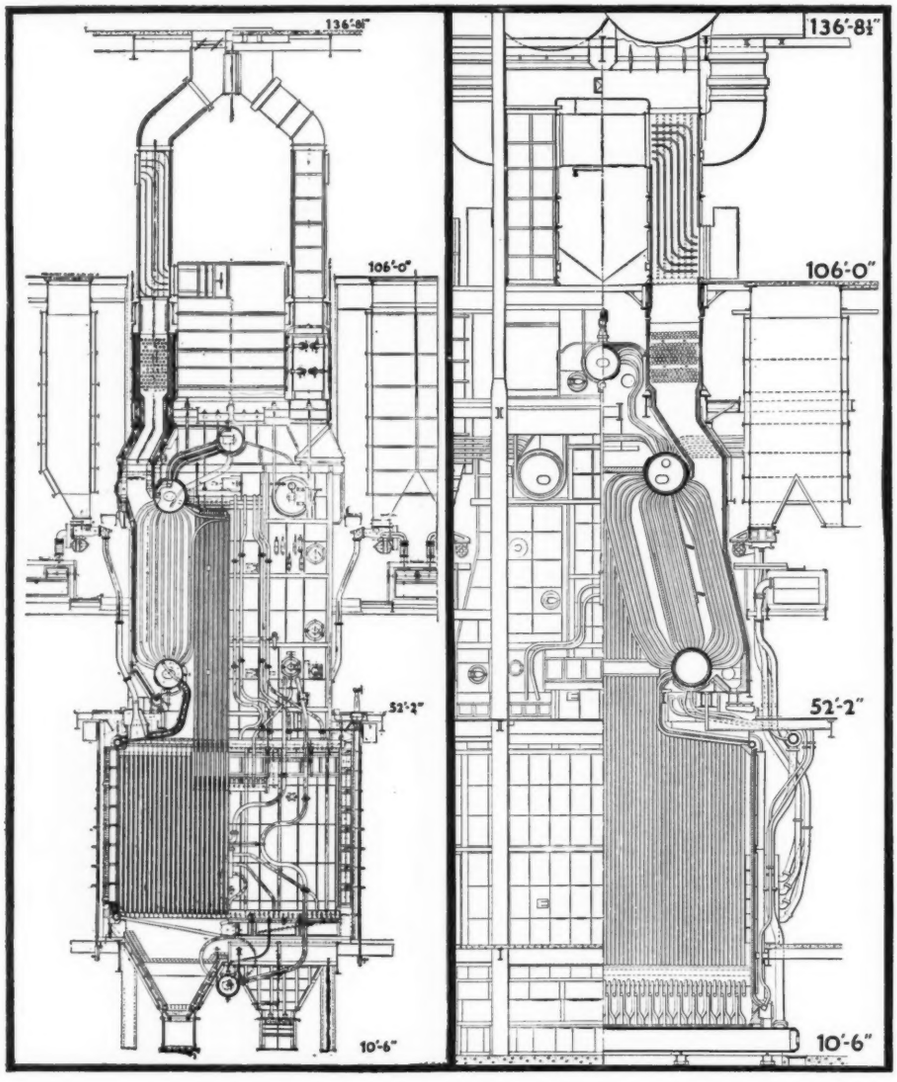
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

August 1930

PROGRESS in DESIGN

results in double the steam output from the same building area

1926 UNIT



1930 UNIT

Three Combustion Steam Generating units each guaranteed to evaporate 325,000 lbs. of steam per hour, were designed in 1926 for the Kips Bay Station of the New York Steam Corporation.

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This unit is guaranteed to evaporate 700,000 lbs. of steam per hour—more than double the guaranteed output of each of the 1926 units.

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Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York

Vol. 52 August, 1930, Section One Number 8

CONTENTS OF THIS ISSUE

International Settlements ..... *Owen D. Young* 743
The Economics of High-Pressure Steam ..... *Geo. A. Orrok* 748
Machining Seamless Forged Steel Drums for High-Pressure Work ..... *J. E. Strachan* 751
Economic Considerations in the Application of Modern Steam Turbines to Power Generation (*Concluded*) ..... *A. G. Christie* 757
The N.A.C.A. Conference at Langley Field ..... *Alexander Klemin* 767
Lubrication Research 772
Casting in Permanent-Mold Machines 775
Tungsten-Carbide Cutting Materials ..... *F. C. Spencer* 777
Symposium on Aircraft Materials 781
Instruments and Apparatus—Part Three—Temperature Measurement 797
25-Lb. Cast-Iron Pipe Flanges and Flanged Fittings 800
Oil and Gas Power at State College 804
The Second World Power Conference 805
Problems in Engineering Education 806

DEPARTMENTAL

Survey of Engineering Progress 787
A Review of Attainment in Mechanical Engineering and Related Fields
Engineering and Industrial Standardization 799
Safety Rules for Gas Equipment With Special Reference to Welding
Work of A.S.M.E. Boiler Code Committee 801
Correspondence 801
Clemens Herschel's Invention of the Fall Increaser
Editorial 802
Growing Obligations; Aircraft Materials; Unemployables de Luxe; New German Flax Fiber; Eddington in Berlin
Book Reviews and Library Notes 808
Group Incentives; Books Received in the Library
Synopses of A.S.M.E. Transactions Papers 811
Current Mechanical Engineering Literature 813

ADVERTISING

Display Advertisements 1
Classified List of Mechanical Equipment 32
Professional Engineering Service Section 120
Opportunity Advertisements 124
Alphabetical List of Advertisers 126

Section Two—News of Mechanical Engineering

Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada, 75 Cents Additional; to Foreign Countries, $1.50 Additional. Changes of Address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on January 17, 1921.

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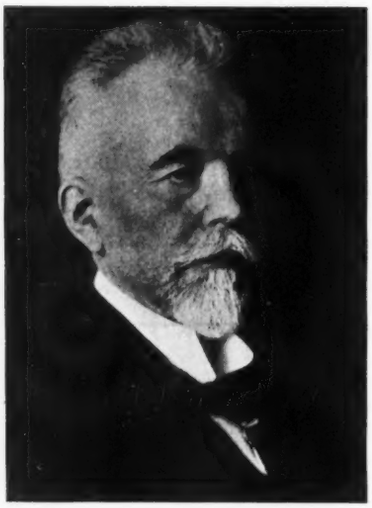
The Engineer's Obligations



WHEN we meet such a number of attractive tasks in all departments of engineering, the question arises as to whether the engineer, absolutely absorbed by his inventive enthusiasm, does not risk neglecting his human obligations. The engineer is a connecting link not only between science and practice, but also between economic leaders and the army of workmen. While he and all are convinced of the necessity of promoting scientific development by every available means, he does not usually tackle with the same intensity his second task—that of social intermediary. Manufacturers of Swiss high-grade products openly acknowledge that it is only possible to attain the highest degree of technical perfection when a cordial understanding between leaders and workers, and consequently a more human and homelike atmosphere in the works, is created. Here new ways open which the engineer has first of all to tread within his limited circle of activity. But he should endeavor, more than hitherto, that his insight and humanitarian feelings influence national legislation. For this purpose he must not remain a one-sided specialist in his own branch, but maintain contact with the intellectual treasures of the world. Equipped in such a manner he will be better able to smooth the path of mankind leading toward the true goal, which is not wealth and enjoyment but intellectual and ethical culture.

AUREL STODOLA.

[From a monograph entitled "The Development of Swiss Engineering and Its Influence on National Welfare and Culture in Switzerland Within the Last 50 Years," by Prof. A. Stodola, in collaboration with Professors Bauer, Böhler, Meyer-Peter, Wyssling, and Dr. Huber-Stockav, presented by Henri Naville at the 50th Anniversary Celebration of the A.S.M.E., Washington, D. C., April 8, 1930.]

MECHANICAL ENGINEERING

Volume 52 August, 1930 No. 8

International Settlements

The Relationship of Politics and Economics in the Efforts to Liquidate the War

By OWEN D. YOUNG,[1] VAN HORNESVILLE, N. Y.

IF ONE were to speak on international affairs, it would be fitting to do so at one or the other of those great ports which furnish our most sensitive contacts with the outside world. Through New York and San Francisco, inward and outward, flow in substantial part the great tides of men and things which constitute international transportation; of voices and records which make up international communication; of finance that essential mechanism which makes all these interchanges possible.

It is true that Washington, as the political focus of the nation, makes our political contacts abroad, but they are relatively superficial and inconsequential compared with these sensitive forces of quick and constant action which represent our participation in the economic activities of the world. So, after the completion of the Dawes Plan, I spoke of my experiences abroad, first in New York. Now, after the completion of the new plan, I consider it a privilege to say my first word at this great port of entry of the West. It is perhaps not inappropriate that it be said as a part of the celebration of this significant anniversary in the life of the University of California.

On the eleventh day of November, 1918, the military forces engaged in the great war suspended operations. For more than four years they had been our masters. They commanded our thoughts and our ambitions; they held as hostages our property and our lives; politics had retired to second place; economics had temporarily been forgotten.

After all, we must remember that politics and economics are not the masters of men—they are their servants. The managers of both too often think and sometimes act as if human beings were merely the fodder of political and economic mills. Merely because I have spoken of economics and politics I would not wish you to think that I consider them in any sense ends in themselves. Back of them stand myriads of human faces, some young, some old, some prosperous, some needy, some charitable, some selfish, some generous, some envious, but all vitally affected not only in their material but in their cultural and spiritual development by these organizations, political and economic, which they have imposed upon themselves.

So long as such organizations render an uplifting service, just so long can we go forward in reaping the advantages which civilization has brought. But those faces in these days of a closely compact world can no longer be segregated into compartments, one of which shall be prosperous and the others not; one of which shall go forward and the others back. Those faces must all move together for good or ill. So politics and economics, their servants, must move together too, not in one country alone, but everywhere. That way only can the benefits of civilization be enlarged—that way only can peace ultimately come.

Politics Takes the Stage

After the military had suspended its act in the tragic drama, politics and economics again came on the stage. Politics, as she advanced to the footlights, had never seemed so charming. She received the applause of all the world. How delightful it was to get rid of that old witch of war who destroyed our wealth and our peace of mind, who murdered our sons and who disarranged all the notions of our daughters! Is it any wonder that Politics commanded our admiration?

What high hopes we had of her! True, there was on the stage also a very modest being, known as Economics. No one paid much attention to her in comparison with their lovely idol. Politics was mistress of the world. And with that setting, the play began.

Politics, conscious of her power and with impatient hand, wrote a treaty while all the world was lost in admiration of her daring. In those days a part of her charm lay in her many moods. One day she spoke through Woodrow Wilson, and the audience sat breathless, moved by the high idealism of a great man and the rich expression of a master. Another day, by contrast, she was hard and cynical, and what the world calls practical, as she spoke through Clemenceau. And still another time she had the delightful abandon and irresponsibility of a mischievous mistress as she was impersonated by Lloyd George. And she had courage, too, because she swept away age-old boundaries and made new ones.

Occasionally was heard the weak voice of Economics modestly protesting here and there, occasionally even offering advice, only to be silenced by the imperious gestures of the leading lady. And one day she decided what Germany should pay by way of reparations the sum of 132,000,000,000 marks, or one-quarter as many dollars. Then it was indeed time for Economics to speak, and she did in protest. But she was quickly silenced by the great party in the Palace of Versailles, the scene of so many grand affairs. Had not Politics always been mistress of Versailles? Had not

[1] Chairman, General Electric Company.

Address delivered at the Charter Day Exercises of the University of California, Berkeley, Calif., March 24, 1930.

Economics always been a scullery maid? Why break the precedent now? Why listen to her in these great councils—and they didn't. And then

> The tumult and the shouting dies
> The captains and the kings depart...

What Politics Could Start but Could Not Stop

Permit me to carry the figure one step further. Politics now goes on tour, always taking her bedraggled associate with her, because even Politics knows that Economics must do the work. Politics in France says, and properly and sympathetically so: Your houses and lands have been destroyed, rebuild them, and do it handsomely—others will pay the costs. That was a program which Politics could start but which Politics could not stop. So the building went extravagantly on, and a few years later, when Germany failed to pay the cost and consequently there overhung France an addition to her vast interior debt, Politics said: We will make Germany pay. We will move our armies into the Ruhr and compel by force the production of coal and manufactured goods for reparations account. But it turned out that the sword was a poor instrument with which to get coal and steel. Politics could put a French army in the Ruhr, but Politics could not take it out.

Politics in England said: If there be people out of work, or even people who do not want work, give them a dole from the public treasury. How generous she was! But there was a program which Politics could start but which Politics could not stop.

Politics in Germany said to Economics: You seem depressed this morning with the great work you have to do. Let me give you a cocktail. I do not intend to get you intoxicated. Take a little stimulant, and after you are started we will cut it out. So Politics gave to Economics inflation. That was something which Politics could start, but which Politics could not stop. As a result the currency of Germany was destroyed and her people were plunged into the depths of want and despair. Yes, it is easy for Politics, with her appeal to the emotions and her ingratiating manner, to start things in the field of Economics which Politics cannot stop.

Economics Summoned

And so it happened in the autumn of 1923. Then, for the first time, Economics got a hearing. The world began to doubt whether Politics, with all her charm, was safe and sound. Losing the applause of her audience, and with that something of her confidence, Politics finally called to Economics and said: If I give you the opportunity will you try to save the show?

The Dawes Committee convened in Paris on the 14th day of January, 1924. Its task was to provide a plan for the balancing of the German budget and for the stabilization of the German currency. It was not permitted to revise the amount of 132,000,000,000 marks which Politics had fixed for Germany to pay. So the Dawes Committee did the very simple thing of fixing the annual instalments which Germany should pay on account of reparations. These being fixed, the budget could be balanced. The Dawes Committee did not specify the number of years which the instalments were to run because that would have determined the amount. No one ever computed the years because it was apparent to the world from the size of the instalments that the earlier reparation figures had been in fact, if not in law, abandoned.

The Dawes Committee brought out its plan on the ninth day of April, 1924. It was made effective on August 16, 1924, at the conference of London, by a treaty signed by the nations which were the beneficiaries of German reparations. By it a new central bank was established for Germany and a new currency was created with an adequate gold supply. And to give you an idea of the results of the inflationary intoxication, let me say that one mark of the new currency was exchangeable for one billion marks of the old currency, and I mean the Continental billion, not ours; that is to say, a million million old marks for one new mark.

The Pen Versus the Sword

And so Economics took the stage in Germany on the first day of September, 1924. A few days later the French armies began to move out of the Ruhr back home. The Germans began to work their mines and factories. The world learned its first great lesson—that economics does not function under political threats or military coercion. It performs obligations which are reasonably fair. It recognizes in the long run only self-interest and honor.

In a word, the world learned that coal and steel for reparations would come at the point of a pen on a checkbook, and would not come at the point of the bayonet in the hands of the soldier. Certainly it was demonstrated that in this field the pen is mightier than the sword.

You all know something of Germany's economic recovery under the Dawes Plan. She paid to her creditors during those five years the full amount set out in the plan, namely, 7,600,000,000 marks, which is the equivalent of $1,917,000,000. Nevertheless, the Dawes Plan was a receivership plan for Germany. It was not a plan of permanent reorganization. Under it S. Parker Gilbert, a brilliant young American, was the receiver, and let me take this opportunity of saying that the success of the Dawes Plan was largely made possible by his wise and efficient administration of the receivership. May I step aside long enough to call the attention of the students of California to the fact that Parker Gilbert was made Agent General for Reparation Payments at the age of thirty-two? He was graduated from Rutgers College in the class of 1912, and from the Harvard Law School in the class of 1915. I speak of it here only because I want you to know that great opportunities and great responsibilities lie before you, not somewhere in the distant future, but almost here and now.

The "Dawes Plan" and the "Young Plan"

As I have said, the Dawes Plan was an interval receivership plan—it did not even fix the total amount of the debt, though all the world knew that the original sum fixed by Politics was quite impossible. Then, too, one could not expect a great nation of 60,000,000 people to function permanently in the hands of a receiver, and so at Geneva on October 20, 1928, Economics was again called by Politics, in the form of an experts' committee, to make proposals for a complete and final settlement of the reparation problem. That committee met on February 11, 1929, in Paris and on June 7 signed and transmitted its report of final settlement. That report is popularly known as the Young Plan.

May I say in passing that this habit of adopting the name of the chairman as the name of the committee began when the first experts' committee was christened the Dawes Committee. General Dawes was not keen about that change of name, but he said, you will remember, that somebody had to take the garbage and the garlands. It was in that same spirit that the Young Committee and the Young Plan were so named—and you may be sure that the chairman will receive more than his fair share of social prestige at the front door and a proportionate amount from the can at the back door, depending wholly on whether the affair is an afternoon tea or the "morning-after" clean-up.

The annual instalment in the standard year under the Dawes Plan was 2,500,000,000 reichsmarks plus a variable resulting from an index of prosperity which was carefully defined in that

plan. This annual instalment was reduced by the Young Plan to an average of 2,050,600,000 gold marks for the first thirty-seven years; that is to say, a reduction approximately of 20 per cent in the flat instalment payments and a complete abolition of any additional sums due under the index of prosperity. The yearly annuities under the Young Plan begin much lower than the average. They start at 1,707,900,000 marks and advance slowly toward a maximum of 2,428,800,000 marks. After the first thirty-seven years, the German instalments gradually diminish from 1,600,000,000 gold marks approximately in 1966 to 897,800,000 in 1988.

Under the new plan, the receivership of Germany is withdrawn. The mortgage of $2,500,000,000 on the German railway system, created by the Dawes Plan, is discharged. The general mortgage on German industry of over $1,000,000,000 is also lifted. Germany is given a specific task to perform. Foreign armies of occupation provided by the political treaty are withdrawn. The Reparation Commission is wound up.

Care was taken in the Plan to avoid the term "reparations." And so at last, ten years after the armistice under the new plan as drawn in Paris, Germany is free. She has a debt to pay, but that is all. Her honor, not her freedom, is at stake.

I have told you that the Dawes payments were reduced something like 20 per cent and the number of years which Germany should pay was also fixed. These instalments, computed at their present value, represented a charge on Germany of something like $9,000,000,000, or 36,000,000,000 marks. Politics, you will remember, fixed Germany's obligations at 132,000,000,000 marks, or $33,000,000,000. In a word, our kitchenmaid, Economics, was compelled to cut the menu of her leading lady by more than 70 per cent to make it fit the prospects of the world's larder.

POLITICS REAPPEARS AT THE HAGUE

At The Hague Politics again appeared, and while protesting that she did not wish to put larger burdens on Germany, did increase somewhat—sufficiently for political purposes, I dare say—the burdens of the Paris Plan; and most of those burdens did, in fact, ultimately fall on Germany. Then, too, at the second Hague conference Politics made another effort to substitute military sanctions for Germany's non-performance, and in a most attenuated form such sanctions were provided.

Dr. Schacht protested, and has recently resigned the presidency of the Reichsbank because he was unwilling to assume responsibility for the execution of a plan which carried burdens additional to those imposed at Paris, and which had any color of military sanctions. Dr. Schacht has been accused in taking this action of having domestic political ambitions. It is fair to him to say that his protest arose, not because there was politics in Dr. Schacht, but because politics had again crept into the Plan.

However, I have no fear of the slight political tinge which the Plan took on at The Hague. Certainly this settlement was better than none. It would have been a great catastrophe for Germany and all the world had the plan agreed upon at Paris by the representatives of all the countries, including Germany, failed in the hands of politics at The Hague. We are all to be congratulated that it did not do so, and perhaps most of all the government of the United States.

AMERICA'S INTEREST THE GREATEST

I speak of my own country, because more than 60 per cent of the total sum to be paid by Germany must find its way to the United States in payment to us of the so-called international debts. You see that was one of our serious problems at Paris. Roughly, one-half of the Dawes payments were needed by the creditors of Germany to pay their debts to the United States. That obligation was fixed. So the entire reduction by the creditor countries in the Dawes payments, so far as their respective budgets were concerned, had to be made out of one-half of the payments; that is, every 5 per cent reduction to Germany in the Dawes Plan payments meant a 10 per cent reduction in the net budget benefits of the creditor countries.

Now a 20 per cent reduction in the Dawes Plan payments looked small to Germany, but a resulting 40 per cent reduction in net budget benefits to the creditor countries looked very large to them. That was one serious problem at Paris.

Another was that the Dawes Plan payments were distributed under what was known as the Spa percentages. Now, as the reduction in the German payments took place, some of the countries, notably Italy, under those percentages, would not have received enough to pay their indebtedness to the United States, while others would have a considerable surplus. Therefore, in order to secure a settlement at all, it was necessary at Paris to remake these percentages.

We not only had to set the total amount which Germany should pay, but we had to redistribute that diminished amount among the creditor countries so that all would be satisfied. The problem of fixing Germany's total amount was not as difficult as the redistribution among the creditors. The German problem was largely an economic one. The redistribution problem was largely a political one.

So, unfortunately, from my point of view, the Young committee in Paris had to deal with these combined problems of economics and politics. If I show some dislike for Politics today, it results largely from my experience with her in Paris. Charming as she may be at times on the stage, she is often petulant and petty in the dressing rooms.

NATURE OF THE FINAL SETTLEMENT

However, as I say, a settlement was made in Paris. It was the best settlement that could be made. Strictly speaking, it was neither an economic settlement nor a political one. It was a compromise between the two.

The compromise was difficult. Both politics and economics in all countries had been waiting for this day of final settlement to even up some of their old scores. Things which had been said and actions which had been taken, things which had been left unsaid and actions which had been withheld, were now to be brought on the stage for the last time.

So, in a sense, our committee at Paris was compelled to review and re-argue, and so far as possible adjust, all of the conflicts involving reparations and their redistribution, and everything collateral thereto which had arisen during the preceding ten-year period. Questions of parity and ratios which are so important in dealing with guns and ships, were not by any means absent in dealing with a limitation program expressed in currency.

Perhaps you will pardon me if I stop here long enough to pay a slight tribute to my associates in Paris. They were men of competence and independence in thought and action. Economic theorists could not dominate them. They had the highest regard for the specialized expert, but they also had experience in making practical application of expert theories. Financial or business interests could not coerce them. They had the greatest respect for men of business, but they were not blind to the large social and political factors also involved. Politics could not control them because they held no public offices and were not responsible to political constituencies.

From such a group only could a settlement come. That does not mean that it could come from these individuals only, but it does mean that any group, to be successful, must have had the qualifications which I have indicated. Then too, the

members of this committee had the good fortune of intimate personal acquaintance. This was a contributing factor to success.

I wish I might take the time to speak of each member of the committee individually and give you some idea of the value of his individual contributions, and particularly I would like to tell you more of my American colleagues. It must suffice here for me to say that no man ever had more competent and loyal partners than I had in J. P. Morgan, Thomas W. Lamont and Thomas Nelson Perkins. The respect in which they held each other and in which they were held by their European associates had a very great influence on our work.

Feasibility of Plan

Whether the burden placed on Germany is too great, only time will tell. It is true that the countries participating in the Paris Plan have added all of their indebtedness to the United States together, and added approximately 50 per cent to it, in fixing the sum which Germany is to pay. Each of those countries, you will remember, had protested against the burden of their indebtedness to the United States, even under the favorable debt settlements made. Yet they have paid Germany the compliment of assuming that she can bear the burden of them all, together with a 50 per cent premium.

But I have great confidence in Germany's capacity to pay. True, she has not a large supply of what the world calls basic raw material. She has, in large measure, however, a supply of that kind of raw material too little taken into account in the world's affairs, namely a capacity for scientific research, and the ability to apply it and organize it in production. It is not unlikely that in the years to come this particular kind of raw material with which Germany is so well endowed may be the reservoir out of which these vast sums will be produced and paid.

If Germany does make the payments out of such a reservoir, the rest of the world must be careful to avoid the enervating effects resulting from the receipt of such payments. We should all remember that the discipline of hard work and of heavy responsibility is likely to do much for a people as well as for an individual. Let no man be sure, let no nation be sure, merely because he is a creditor of another's labor, that therefore he is strong and will always remain so.

Bank for International Settlements

The most striking feature of the new plan is the Bank for International Settlements. That institution is unlike anything which has existed in the world before. It was not created merely for the sport of inflaming the imaginations of men, as one might think from the discussions, or even for the laudable purpose of providing a new subject for the debaters of the world. Like all inventions and new creations, it arose out of the mind of man to meet a new need.

Obligations, as I have said, are to be delivered by Germany of $9,000,000,000 approximately, payable over a period of nearly sixty years, in fixed annual instalments. As these obligations mature, vast sums must be paid over the frontiers and translated into the currencies of other countries. Who should hold these obligations and control these transfers?

Should they be put in the hands of political treasuries of more than a dozen nations, where, in case of slight difficulties, they might become the football of domestic or international politics? Even more dangerous would it be to have them become the trading medium in all kinds of international negotiations.

Should they be left where Germany, if she chose, might default in the payments to one power and continue those to another?

Should they be left where these transfers in political hands might become a menace to the normal economic exchanges of the world?

No, it was quite apparent, in the interest of all, creditor and debtor alike, that these obligations of Germany should be held and the payments managed by a single organization for the account and benefit of all. Any default by Germany must be a common default for all creditors. Any moratorium must be a common moratorium. Therefore, it seemed to our committee necessary to mobilize the German obligations in single hands.

For that purpose the Bank for International Settlements was created. Any difficulties in German payments must be between Germany and the bank. The bank should be, as far as possible, insulated from politics, both domestic and international, and be free from government domination and control. To accomplish this, the charter and by-laws of the bank were established by international treaty and evidenced by a protocol signed at The Hague, on January 20 of this year. Corporate entity is to come into existence by an act of the Legislature of Switzerland, where the bank is to be located, Switzerland being a party to the treaty.

Bank's Powers Important but Limited

The capital of the bank is to be $100,000,000, and its stock is to be sold in the principal countries of the world. Its directorate is to consist principally of the governors of the central banks of Europe, or their nominees, America having declined to participate.

The earning power of the bank is to come from small commissions on reparation payments, and certain deposits from governmental treasuries provided in the Plan. The bank has power to accept deposits from or to make deposits in central banks of countries on a gold exchange basis. Thus the endeavor has been made in the interest of the world to eliminate politics from the control of reparation payments and from the machinery which will handle them. The bank is to be truly the insulator between the political treasuries of the creditor powers and their debtor, Germany.

The bank is in no sense a super-bank. It cannot operate in any country in which the central bank of that country objects. It cannot issue demand notes in any form, and therefore there is no danger of an international currency.

It may be used as a clearing house by central banks to the extent which they may elect to do so. This lies in the future. But there is no question in my mind that some such development will come if the diminishing supply of gold in the world threatens a general deflation in the price level. The proper handling of price stability is one of the most important matters facing the capitalistic system today. In it will be found the roots of those maladjustments which result in the unequal and unfair distribution of wealth, in unemployment and other serious problems.

The International Bank may turn out to be an essential and useful piece of machinery for an economic world which of necessity is becoming more and more closely integrated. Politics becomes dangerous on a stage so small unless economics functions well. Fortunately, the bank has the power of growth but it will grow only as our needs compel it. It will grow only as the central banks of the world wish to use it. In a word, it is the servant of all and the master of none.

Bank Independent of the League

Another sensitive question which has been raised is whether the League of Nations and the Bank for International Settlements might not unite their forces. The League represents international political cooperation, and the bank international financial cooperation. Well, if that means that the bank will come under the domination of the League, and so there will be added to the political forces of the League the financial resources

of the bank, I think we may dismiss once and for all our fears if we are opposed to the League, or our hopes if we are its proponents.

Nothing is clearer, from the experience of the last ten years, than the necessity of keeping our economic machinery, and especially our finance, free from the domination and control of politics. That seems to me one great lesson which we have learned. I do not mean that the struggle of politics to control economics is ended. It is going on in every country, and will continue to do so.

ECONOMIC INTEGRATION A PREREQUISITE TO POLITICAL COOPERATION

But what about the relationship of economics to politics in international cooperation? Well, my answer is this: Economic integration of the world is a necessary prerequisite to effective political cooperation in the world. America, as the greatest creditor nation, is more interested than any other in economic integration. It is inevitable that from an economic point of view she take an interest in and be concerned in the material problems and affairs of every country on the globe.

Isolation to America, either economic or political, is quite impossible. The material development of countries will necessarily be to us a matter of great concern, both from an idealistic and practical point of view. If all peoples everywhere could be lifted in productive capacity and consuming power to a point equal to our own, envy and hatred would be alleviated; capital would be better employed, markets would be enlarged, unemployment would diminish, and a much more peaceful world would be insured.

Let no man think that the living standards of America can be permanently maintained at a measurably higher level than those of the other civilized countries. Either we shall lift theirs to ours or they will drag ours down to theirs. Tariffs and other petty political barriers, temporarily justifiable, will in the long run only accentuate the trouble.

Our experience at home during the last generation should teach us that segregation into different groups for the selfish purpose of benefiting one at the expense of the other is a failure. It was not so many years ago that our industrial leaders in the United States thought that a low wage scale was necessary to enable capital to earn a profit. Now we have learned that a high wage scale may be consistent not only with low production costs but also with the greatest security to and return on capital investment.

THE WELFARE OF ALL AS AN OBJECTIVE

In a word, we are learning in America that the highest welfare of all rather than of any class is a wise objective even for the group previously privileged. How long will it take us to learn that fact in a world so small that Commander Byrd talks from New Zealand on Wednesday, in the fall of the year, with Adolph S. Ochs in Schenectady, on Tuesday in the spring of the year—and that conversation can be heard by practically everybody in the world at varying times and seasons.

To secure the advantages of economic equilibrium we must go beyond political frontiers. We may sign great declarations of peace, but we shall concurrently find, if we follow a narrow economic policy, an increasing resistance in countries less well off than ourselves to that disarmament which is the insurance of the peace we seek. Politics in America may start a program on a narrow economic policy which politics cannot stop.

After all, we must remember that politics and economics are not the masters of men—they are their servants. The managers of both too often think and sometimes act as if human beings were merely the fodder of political and economic mills. Merely because I have spoken of economics and politics I would not wish you to think that I consider them in any sense ends in themselves. Back of them stand myriads of human faces, some young, some old, some prosperous, some needy, some charitable, some selfish, some generous, some envious, but all vitally affected not only in their material but in their cultural and spiritual development by these organizations, political and economic, which they have imposed upon themselves.

So long as such organizations render an uplifting service, just so long can we go forward in reaping the advantages which civilization has brought. But those faces in these days of a closely compact world can no longer be segregated into compartments, one of which shall be prosperous and the others not; one of which shall go forward and the others back. Those faces must all move together for good or ill. So politics and economics, their servants, must move together too, not in one country alone, but everywhere. That way only can the benefits of civilization be enlarged—that way only can peace ultimately come.

And one word more. America is too rich to be loved. She is well enough off to be envied. The attitude of the world toward her will be largely influenced by her spirit. If it be one of selfishness in isolation, she will have failed in her success, she will have misused the things which God has given her.

I pray for sober and sensible responsibility in this America we love, a spirit of gratitude for the things we have, a spirit of friendliness and helpfulness and cooperation for all, a spirit of restraint in the use of any power which has been entrusted to us, and most of all, restraint in speech.

> If drunk with sight of power we loose
> Wild tongues that have not Thee in awe,
>
> * * * * * * * * * * *
>
> For frantic boast and foolish word
> Thy mercy on Thy people, Lord.

Training of an Engineer

FOR years past a gentle but insistent pressure has been directed against the necessity of workshop training for young engineers who have had a college education. It is, we think, based on an erroneous conception of mechanical engineering. The student straight from the lecture hall and the classroom, possibly glorying in the honor of a recently conferred degree, believes, not unnaturally, that the practice of science and all that it connotes is the principal occupation of the engineer. In a few years he learns his mistake. He discovers that, while science plays an important part, it is only half the battle. Only now and then does he find that he is called upon to use precise science, though all his thoughts must be directed by the scientific method. He awakens to the fact that workshop knowledge is of more importance in the direction of a factory than most of the things that he has learned in college. There he will have been taught very little about organization for output and nothing about workshop methods which depend upon local conditions. In the works he will find that among his most important teachers are men who come round with something to sell—a new machine or a new accessory—and he will discover that the adoption of the best is limited by financial and economic considerations. He learns, too, that "hit and miss" development is the common method of progress in mechanical engineering. Above all he will gain acquaintance with the fact that the principal "machines" in all factories are the men themselves, from the managing director to the laborer "on the floor." These are the things that fill his life; by his understanding of them he succeeds.—*The Engineer*, June 10, 1930, p. 689.

The Economics of High-Pressure Steam

By GEO. A. ORROK,[1] NEW YORK, N. Y.

This paper shows the range between the theoretical Carnot-cycle efficiency, the practical efficiency, and the thermal economy actually obtained in the central station for pressures up to the critical point and temperatures up to 1000 deg. fahr. (538 deg. cent.). Cost considerations are reviewed, and it is shown that for American conditions there will be little difference in fixed charges. Operating costs are discussed, showing little difference for equal cost of raw fuel. The manifest advantages of high use factors are stressed. The differences between the practical and theoretical economies are shown, and the conclusion is drawn that the greatest chance of major savings lies in careful operation and a high use factor.

IT IS now more than a century since Carnot definitely proved that a heat engine working between two absolute temperatures could not exceed the efficiency given by the formula $(T_0 - T)/T_0 = \eta$. Since a kilowatt equals 3412 heat units, the maximum thermal efficiency of a perfect heat engine is given by

$$\frac{3412\ T_0}{T_0 - T} = \text{B.t.u. per kilowatt-hour}$$

and this value has been the criterion by which the performance of any thermal power plant has been judged. This efficiency could not be reached since most thermal plants worked on the Rankine or Clausius cycle, but Thurston and Stanwood pointed out many years ago the value of the regenerative cycle with its recirculated heat. Later the reheat cycle had been exploited, also combination cycles of various kinds, many of which approach the Carnot cycle in efficiency. When the question is of a complete power plant instead of a heat engine, other losses come in to complicate the situation, making it a difficult problem to delimit the maximum attainable thermal efficiency. In Fig. 1 the author has shown the curve of Carnot efficiency, using the normal summer temperature, 70 deg. fahr., as the low limit. The abscissas are the upper temperatures of superheat, while the ordinates are B.t.u. per kw-hr. It will be noted that the curve is flat, the ordinate being 7800 B.t.u. at 500 deg., and 5400 B.t.u. at 1000 deg.

When we consider the regenerative-reheat cycle and water vapor as the medium, in which a portion of the heat is imparted to the fluid at or below the saturation pressure while the remainder is used in the superheat and reheat range, the curve of thermal efficiency flattens still more, and curves must be drawn for each pressure. These are shown by the dotted lines, and a thermodynamic efficiency of 85 per cent is assumed. For any one pressure the efficiency changes are slight, not exceeding 500 B.t.u. over a wide range.

But a thermal-electric plant has other losses inherent in its operation, which must be considered in any such analysis. The operation of the boiler plant under test conditions has shown an efficiency as high as 92 per cent on the high heat value of the fuel. Let us consider 90 per cent as the possible yearly average. Auxiliaries consume power, for which 5 per cent is a fair allowance, and let us take 97.5 per cent for the generator efficiency and 97.5 per cent for the pipe and connection efficiency. Multiplying these together gives 81.2 per cent as the further reductions for station efficiency. The author has used 80 per cent, allowing for radiation and unaccounted-for losses, and on this basis has drawn (Fig. 1) heavy curves for the five chosen pressures. The points marked *R* are those to the right of which reheat will not be necessary and has not been figured.

In Fig. 2 the thermal savings over 200 lb. pressure operation have been plotted for 750 deg. and 1000 deg. temperature, as well as the savings at any pressure for an increase of pressure of 100 lb. The increment savings amount to roughly 800 B.t.u. at 200 lb., 100 B.t.u. at 1200 lb., and 50 B.t.u. at 1800 lb. and above. The shorter curve is the increment thermal saving due to doubling the pressure at any pressure up to 1600 lb., and these values vary between 1400 B.t.u. at 200 lb. and 700 B.t.u. at 1600 lb. Using 1000 deg. fahr. as the maximum temperature, most of the available chances for saving have been made when 750 to 800 lb. has been reached, and from that point the savings show increasingly smaller values. The heavy curves of Fig. 1 bring us to the same conclusion.

Actual figures from Edgar and Lakeside (Table 1) show the close correspondence between theory and practice when due allowance is made for another factor of striking importance, i.e., the use factor. The author has previously called attention to this point (see Paper 124, Japan Sectional Meeting, W.P.C., 1929), and Table 1 is partly reproduced from that paper. It will be noted that two stations, Columbia and Long Beach, operating at relatively low pressures—600 lb. and 409 lb.—but with high use factors, show better thermal economy and a larger ratio of heat utilized.[1] Some of the other lower-pressure stations report good efficiencies, but the use factor is lower, so the thermal efficiency does not approach so closely the theoretical. This well-known trend was established by Patchell in 1905, by Klingenberg in 1913, and by R. P. Parsons in 1914. It has been proved under various conditions for stations of homogeneous design, i.e., where turbines and boilers of one date and design are used. There are other American stations of nearly equal economy for which the operating data have not been released.

In the Japan paper quoted above, it was stated that the installation costs of high-pressure stations were generally six to ten per cent higher than for low-pressure stations. Further investigation shows that this increase of cost tends to disappear with each new high-pressure installation, the published figures for Deepwater and Harmon showing only a five per cent increase over standard practice. When it is remembered that the station structure accounts for about 45 per cent, while the electrical side may represent 25 per cent of the cost, it is fair to say that in the future high-pressure stations with large units will cost no more than standard stations, and that there will be little if any difference in fixed charges for any given use factor. Reports

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E. Mr. Orrok was for many years mechanical engineer for the New York Edison Company, being responsible for the design of numerous power plants. He has served as consulting engineer for many companies, specializing in power generation, coke ovens, water power, and many other mechanical and chemical applications. He has made a study of European engineering practice in connection with power plants. He has served as consulting professor of steam engineering at the Brooklyn Polytechnic Institute, and as graduate lecturer in steam engineering at Yale University. Since 1927 he has lectured on steam engineering at Harvard University.

Presented at the Second Plenary Meeting of the World Power Conference, Berlin, Germany, June 16–25, 1930.

TABLE 1 OPERATING DATA OF POWER STATIONS

	Columbia	Philo	Long Beach	Cahokia	Hell Gate	Padiham	Edgar	Lakeside
Installed capacity, kw	90,000	80,000	100,000	145,000	285,000	30,600	142,150 (13,150 B.P.)	234,000 (14,700 B.P.)
Monthly output, 10^6 kw-hr	48.6	36.07	59	38.57	82.9	6.01	.....	83.0
Load factor, per cent	76.0	71.5	89.35	55.7	66	65.7	.....	.....
Steam pressure, lb. per sq. in. gage	600	530	409	304	265	250	350 (1300)	300 (1200)
Steam temperature, deg. fahr.	730	706	735	700	610	620	700 (730)	700 (725)
Vacuum, in. Hg	29.3	29.0	28.51	29.2	28.5	29.3	29.0	29.0
Theoretical cycle efficiency, per cent	44.0	42.3	40.9	39.6	35.1	35.2	43.5[a]	41.4[a]
Actual thermal efficiency, per cent	27.3	24.0	26.6	20.2	19.4	20.66	25.7	23.0
B.t.u. per kw-hr., theoretical	7760	8070	8350	8620	9730	9700	7850[a]	8250[a]
B.t.u. per kw-hr., actual	12,495	14,250	12,848	16,895	17,630	16,515	13,300	14,830
Station loss, B.t.u. per kw-hr.	4735	6180	4498	8275	7900	6815	5450	6580
Ratio of thermal to actual efficiency, per cent	66.6	56.7	65.0	51.0	55.3	58.8	59.0	55.6
Year of design	1924	1922	1927	1923	1919	1925	1923	1924
Station capacity factor, per cent	72.7	60.7	89.35	35.8	39.4	26.4	.....	.....
Theoretical reduction of B.t.u. per kw-hr. due to superimposed high-pressure cycle	..	..	..	..	..	..	1180	1400
Station proportion of high-pressure cycle in per cent theoretical/per cent realized	..	..	..	..	..	..	45/55	28.1/28
Realized reduction in heat rate, B.t.u. per kw-hr.	..	..	..	..	..	..	1030	975

[a] Weighted average. B.P.—Back pressure.

TABLE 2 HIGH-PRESSURE POWER STATIONS

(Steam pressure, 500–800 lb. per sq. in.)

Name	Year	Steam conditions at throttle: Pressure, lb. per sq. in.	Steam conditions at throttle: Temperature, deg. fahr.	Kw. total (high-pressure unit)	Company	References
Philo	1924	550	700 R.	..... (165,000)	Ohio Power Co.	Prime Mov. Com. Report, 1929
Twin Branch	1925	600	725 R.	90,000	Am. Gas & Elec. Co., South Bend, Ind.	Prime Mov. Com. Report, Aug., 1929
Columbia	1925	600	720 R.	108,000 (63,000)	Columbia Power Co., Cincinnati, Ohio	Prime Mov. Com. Report, Aug., 1929
Crawford Ave.	1925	550	720 R.	421,000 (104,000)	Commonwealth Edison Co., Chicago	Prime Mov. Com. Report, Aug., 1929
Stanton	1927	600	725 R.	50,000 (50,000)	Exeter Power Co.	Prime Mov. Com. Report, Aug., 1929
Waukegan	1927	600	750 R.	115,000	Pub. Service Co., N. Illinois	Prime Mov. Com. Report, Aug., 1929
Solvay Process Co.	1927	804 165	750	(5,000 B.P.)	Syracuse, N. Y.	*Power*, May 28, 1929
Grand Avenue	1928	600 185	750	..... (10,000 B.P.)	Kansas City P. & L. Co., Kansas City, Mo.	Prime Mov. Com. Report, Aug., 1929
Powerton	1928	600	725 R.	110,000 (55,000)	Super Power Co. of Illinois, Pekin	Prime Mov. Com. Report, Aug., 1929
State Line	1929	650	730 R.	208,000 (208,000)	State Line Gener. Co.	Prime Mov. Com. Report, Aug., 1929
Waldorf Paper Co.	1929	650	...	(3,000 B.P.)	St. Paul, Minn.	*Power*, May 28, 1929
West Virginia Pulp & Paper Co.	1929	600	...	.....	Tyrone, Va.	*Power*, May 28, 1929
Michigan	1930	650	750 R.	(64,000)	North Indiana Pub. S., Michigan City	Prime Mov. Com. Report, Aug., 1929

R.—Reheat. B.P.—Back pressure.

TABLE 3 HIGH-PRESSURE POWER STATIONS

(Steam pressure, 800–1800 lb. per sq. in.)

Name	Year	Steam conditions at throttle: Pressure, lb. per sq. in.	Steam conditions at throttle: Temperature, deg. fahr.	Kw. total (high-pressure unit)	Company	Reference
Edgar	1925	1300 (350)	730 R.	..... (10,000)	Edison Elec. Ill. Co. of Boston	Prime Mov. Com. Report, Aug., 1929
Lakeside	1926	1200 (300)	725 R.	..... (14,700 B.P.)	Milwaukee El. Ry. & Light Co.	Prime Mov. Com. Report, Aug., 1929
Northeast	1927	1200 (300)	725 R.	..... (10,000 B.P.)	Kansas City P. & L. Co.	Prime Mov. Com. Report, Aug., 1929
Deepwater	1930	1200	750 R.	..... (53,000)	U. G. I., Deepwater, N. J.	Prime Mov. Com. Report, Aug., 1929
Holland	1930	1200	750 R.	..... (55,000)	N. J. Power & L. Co., Dover, N. J.	Prime Mov. Com. Report, Aug., 1929
South Amboy	1930	1250	750 R.	..... (25,000)	Jersey Centr. Power Co.	Prime Mov. Com. Report, Aug., 1929
Station "A," San Francisco	1930	1200	750 R.	110,000 (55,000)	Pacific Gas & Elec. Co.	Prime Mov. Com. Report, Aug., 1929
Philip Carey Co.	1930	1450 (60)	825	..... (12,000 B.P.)	Lockland, Ohio	
River Rouge	Ordered	1200	725 R.	..... (110,000)	Ford Motor Co.	*Gen. Elec. Rev.*, Jan., 1930
.....	Ordered	1300 (380)	725 R.	47,000 (12,000 B.P.)	Houston L. & P. Co.	*Gen. Elec. Rev.*, Jan., 1930
.....	Ordered	1400 (360)	... R.	3,700 B.P.	Dow Chem. Co., Michigan	*Power*, Jan. 7, 1930
.....	Ordered	1400	810	?	S. Antonio Gas & Elec. Co.	*Power*, Jan. 7, 1930
State Line	Ordered	1200	750 R.	275,000	State Line Gen. Co.	*Electrical World*, Feb. 1, 1930

R.—Reheat. B.P.—Back pressure.

from all users of high-pressure apparatus agree that labor and maintenance costs are the same for both high- and low-pressure installations, and these comparisons are now possible over considerable periods of time and for a number of different conditions.

The function of the central station is to supply power when it is wanted, in such quantities as are wanted, at the cheapest possible unit cost. The increasing of thermal efficiency is one of the ways in which cost of power may be cheapened, and in America this process has been continuous since the first central station was built with a thermal efficiency of about two per cent. The average of all stations in 1929 was about 17 per cent, while the best station operated at around 27 per cent. This increase

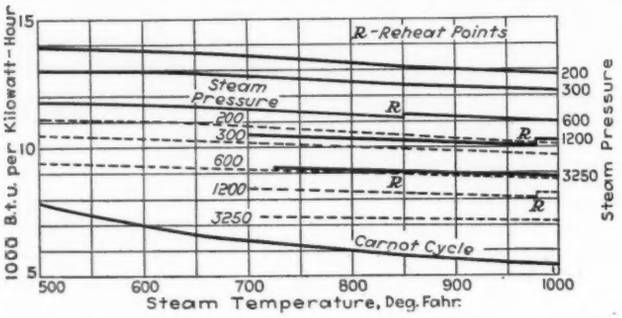


FIG. 1 EFFICIENCIES OF CARNOT AND REGENERATIVE CYCLES—ALSO EFFICIENCY OF PRACTICAL CENTRAL-STATION CYCLE

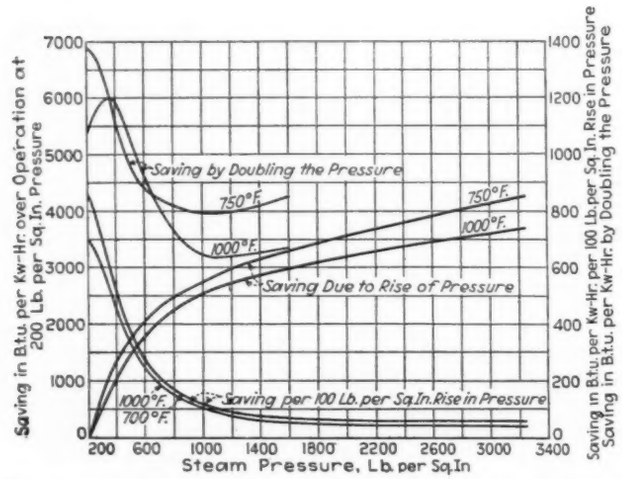


FIG. 2 CURVES SHOWING SAVINGS DUE TO INCREASE OF PRESSURE AND TEMPERATURE

of thermal efficiency corresponds to a reduction in the use of fuel from 12 lb. per kw-hr. to about 0.9 lb. per kw-hr. That we are approaching the limit of fuel saving is well known and is shown by the curves in Figs. 1 and 2.

Other savings of nearly as marked a character have been made in the cost of oil, waste and supplies, water, maintenance, and labor. Statistics published lately show that these charges are small and nearly proportional to the station output.

The only other way to cheapen the cost of power is by reduction of the unit fixed charges, and this is a question of the use of the installation. The larger the divisor (kw-hr. per kw. of installation; hours of use) the lower the unit cost. In the case of a station using 1 lb. of coal per kw-hr., an increase of hours of use of 500 hours per year at ordinary use factors may mean a greater saving than a reduction of 20 per cent in the thermal economy.

The curves in Fig. 1 show that 9000 B.t.u. per kw-hr. will probably be the absolute minimum to be secured from a high-pressure station. Taking our previous experience into consideration, it is unlikely that 10,000 B.t.u. will be exceeded—and present-day plants are within 20 to 25 per cent of this. This last increment of cost must be had by careful design and construction coupled with the best operation attainable, and economic results predicate the largest use factor attainable, and base-load operation with as few and as large units as may be available.

The foregoing analysis shows that:

1 Thermal economies gained by raising pressures are considerable in the lower ranges, but above 1500–1600 lb. become of lesser value.

2 Thermal economies gained by increasing temperatures have much smaller values which maintain throughout the range investigated.

3 The installation costs per kilowatt, while now somewhat higher for the higher pressures, are apparently equalizing as the machinery is being standardized.

4 There is less variation between operation and maintenance costs of high- and low-pressure stations than between the same costs in individual low-pressure stations.

5 Commercial economies include both operation and fixed charges, and commercial savings follow high use factors.

6 The cheapest cost of power predicates high use factor, low fuel cost, and high pressure and temperature.

Power Plants of Tomorrow

ACCORDING to F. D. Newbury (Manager, Power Engineering Department, Westinghouse Electric & Manufacturing Co., Mem. A.S.M.E.), a significant trend in large turbo-generators is toward larger and larger size. Few new propositions from the utilities call for main generating units of less than 100,000 kw.

Single-unit, air-cooled, 1800-r.p.m. generators can be built for ratings up to 200,000 kva. With hydrogen as the cooling medium, single generators up to 250,000 kva. can be supplied without increasing the essential dimensions of the 200,000-kva. air-cooled generator.

Geo. A. Orrok (Consulting Engineer, Mem. A.S.M.E.), thinks that attractive reductions in fixed and operating charges may be expected with the increase of temperatures to, say, 1000 deg. fahr., and the elimination of reheating which will be made possible with the steam pressure range from 500 to 750 lb. Persistent efforts being made both here and abroad to develop drumless steam generators of the coil type should bring the cost of the steam generator somewhat lower, making high pressures economically available for smaller industrial plants. One of the most important questions with high-pressure steam operations is the treatment of feedwater. Progress made in the last three years has been highly satisfactory.

According to D. S. Jacobus (Advisory Engineer, Babcock & Wilcox Co., Mem. A.S.M.E.), during the last twenty-five years steam pressures in central power plants have raised from 225 lb. per sq. in. as a maximum to more than 1400 lb., and superheated-steam temperatures from about 500 deg. fahr. to 800 deg. fahr. and above. The capacities at which boilers are operated have increased from about 50,000 lb. of steam per hr. to 500,000 lb. or, where two boilers are placed over the same setting, to the neighborhood of 1,000,000 lb. The overall efficiency of the boiler and its appurtenances has increased from about 75 per cent to 85 per cent and more.

Boiler manufacturers are prepared to build boilers for still higher pressures and steam temperatures whenever there is an economic need.—*Electrical World*, vol. 95, no. 23, June 7, 1930, pp. 1136–1138.

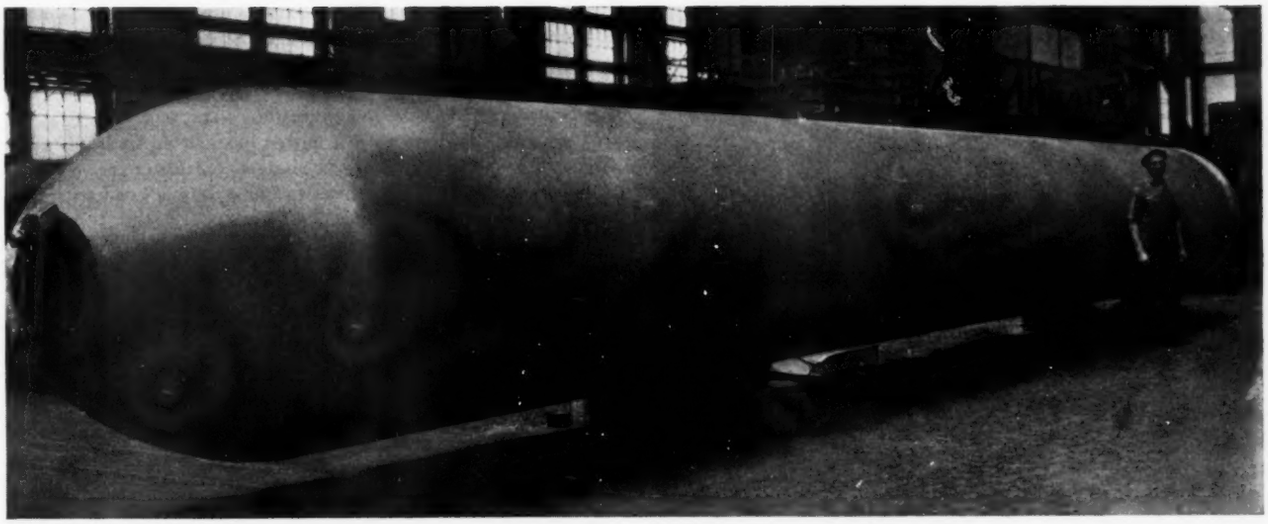


FIG. 1 COMPLETED HOLLOW-FORGED STEEL HIGH-PRESSURE BOILER DRUM
(Outside diameter, 60 in.; inside diameter, 52 in.; length, 41 ft. 9 in.; weight, 106,920 lb.)

Machining Seamless Forged Steel Drums for High-Pressure Work

BY JOHN E. STRACHAN,[1] PHILADELPHIA, PA.

DURING the past few years there has been a tremendous development of processes in many lines of industry requiring the use of high pressures, and often not high pressures alone but high pressures at high temperatures.

The requirements long ago became such that the capacities of the old type of riveted, and the more recent type of welded, vessels were far exceeded.

A new type of vessel or container which would safely meet the requirements had to be developed, and there arose a demand for large, hollow-forged, seamless drums or cylinders. The requirements for size, pressures, and temperature are constantly increasing. Drums so large that a few years ago it would have seemed impossible to make them are being successfully manufactured, in some instances of alloy steels, in order to meet these demands. Commercial vessels are actually in operation at a pressure of 75,000 lb. per sq. in. at atmospheric temperature, and at 15,000 lb. per sq. in. at 1100 deg. fahr.

It is the machining, not the manufacture, of large drums as done by The Midvale Company that will be dealt with in what follows. In order to preserve the continuity of the story, however, other operations will be mentioned.

As it seemed advisable to have a concrete example to follow through the various operations, a Babcock & Wilcox high-pressure boiler drum has been chosen as being typical but only that part of the work done at Midvale will be considered.

The drum selected, shown completed in Fig. 1, was for a working steam pressure of 1405 lb. per sq. in. and was tested hydrostatically to 2810 lb.

Fig. 2 shows a huge open-hearth ingot for one of these drums being poured, and Fig. 3 the resulting ingot. This ingot was an 82-in. octagon with a length of body of 164 in. The body weighed 256,000 lb., and the tong hold, 45,000 lb., or a total of 301,000 lb.

The amount of top scrap cut averages somewhere in the neighborhood of 25 per cent, and the bottom scrap, 5 per cent.

Before starting to hollow-forge the ingot into a cylinder it must have a longitudinal hole through its center, through which to put the mandrel on which it is forged. At Midvale most of these holes can be made under a press as shown in Fig. 4, but they are sometimes bored.

When it is to be bored, the ingot is sent into the shop as cast. The tong-hold end is chucked in a pot chuck bolted to the faceplate of a lathe (Fig. 5), the bottom end being run in a revolving rest.

The pot chucks which are used in most of the lathe operations

[1] Superintendent of Machine Shops, The Midvale Company, Nicetown. Mr. Strachan was graduated from the University of California, College of Mechanical Engineering in 1895. He entered the drafting room and shops of the Union Iron Works in California, remaining there until 1898. In 1899 he erected machinery for the hydroelectric plant of Toulumne Co., California. After spending a short time with Baker & Hamilton in San Francisco, as sales engineer, he returned to the Union Iron Works in the mining-machine department. In 1903 he established with Edward Fowler and John Young, the Pacific Foundry Company. For one year he was engineer with the Bewick Moreing Company of Kalgoorlie, West Australia, of which company the Honorable Herbert Hoover was a partner. His association with The Midvale Company began in 1904 as foreign sales representative, and he was resident sales manager in turn in Mexico, Australia, and London. Since 1915 he has been in the machine shops of this company.

Presented at a meeting of the Philadelphia Section of the A.S.M.E., November 26, 1929.

are cylindrical steel castings, flanged for bolting to the faceplate. The largest one will take a diameter of 111 in. Rows of setscrews through the cylindrical shell are sledged up to drive the

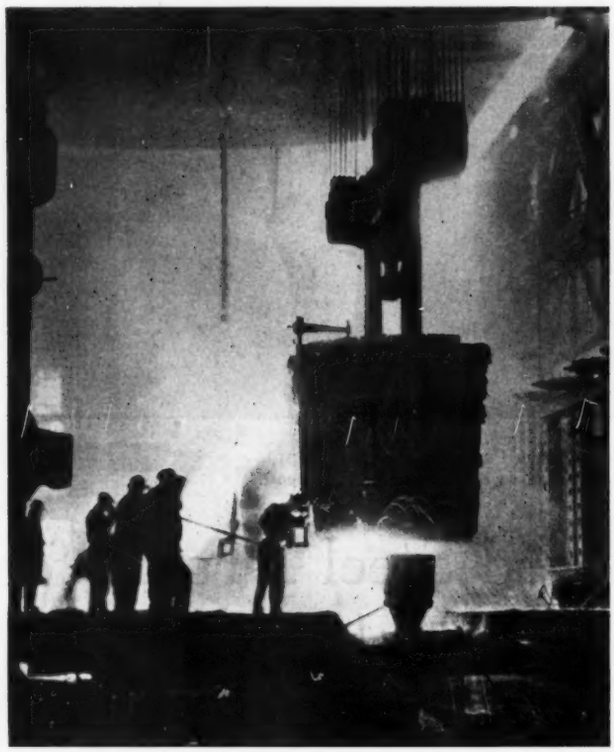


FIG. 2 POURING THE HUGE OPEN-HEARTH INGOT

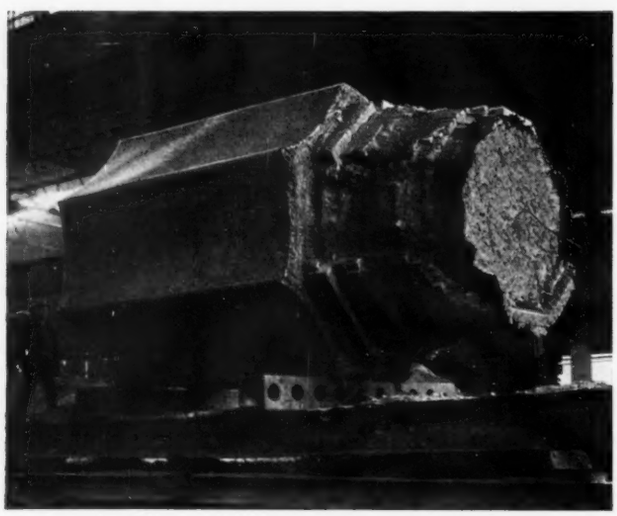


FIG. 3 THE INGOT AS CAST
(An 82-in. octagon 164 in. long. Total weight of body and tonghold, 301,000 lb.)

job. Usually V-type driving blocks are inserted between the screws and the job. These blocks not only hold better but provide a means of driving various-sized jobs with the same length of setscrews. The job is set to run as desired, exactly as in any chuck.

The revolving rests are spools running in bearings somewhat similar in construction to a steady rest, but having a complete bearing instead of jaws. The bearings are spherical to facilitate alignment. The job is held and set by setscrews through the outer edges of the spool. The company's largest revolving rest takes a $82^1/_2$-in. diameter and has two rows of four $3^1/_2$-in.-diameter setscrews with acme threads.

The boring is done with a cutter head fitted in front with a carbon-steel cutter. High-speed-steel cutters over 8 in. in diameter have proved too brittle, and a double head with high-speed cutters is now being developed. Cutting compound is pumped through the bar to the cutting edge of the cutter under a pressure of about 75 lb. The cutting compound also carries the chips back out of the hole.

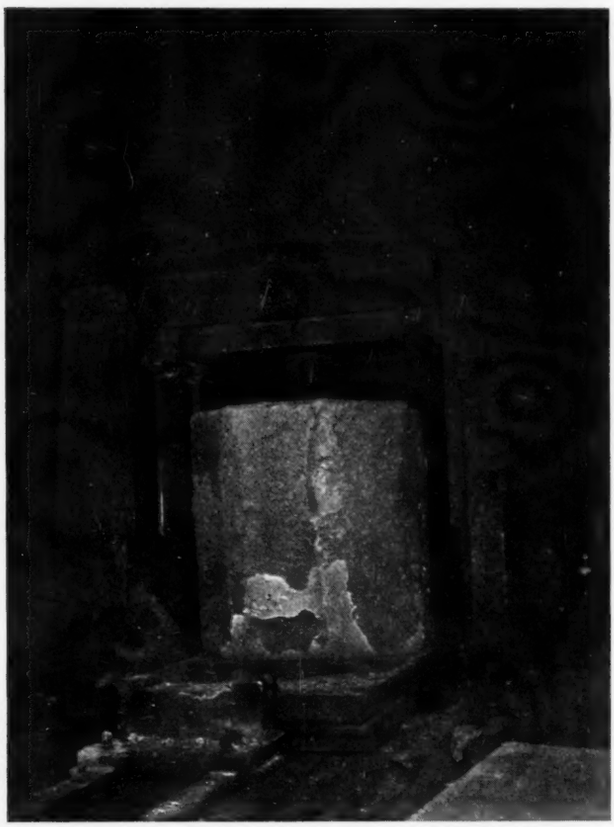


FIG. 4 PUNCHING LONGITUDINAL HOLE THROUGH INGOT

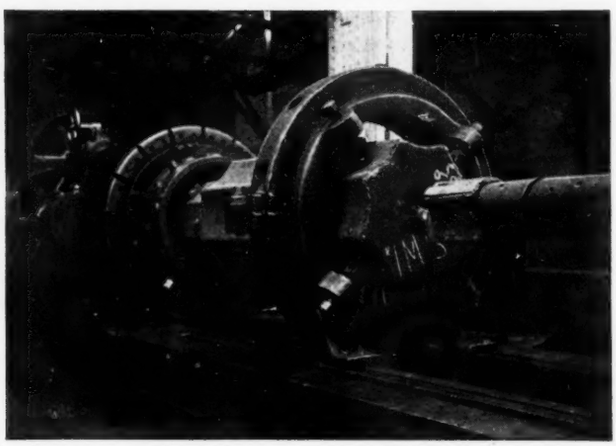
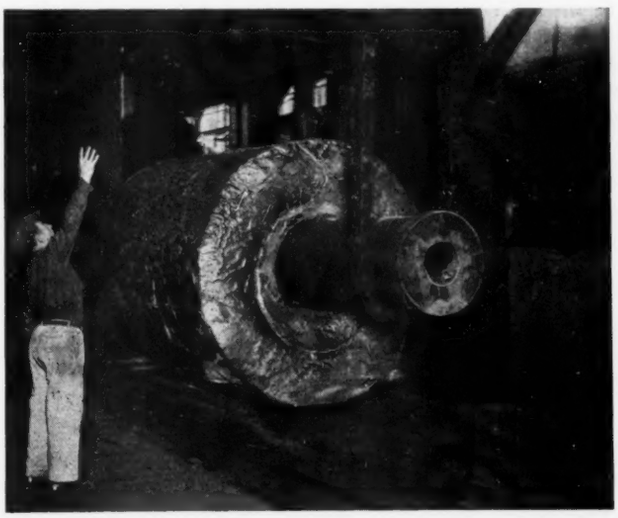
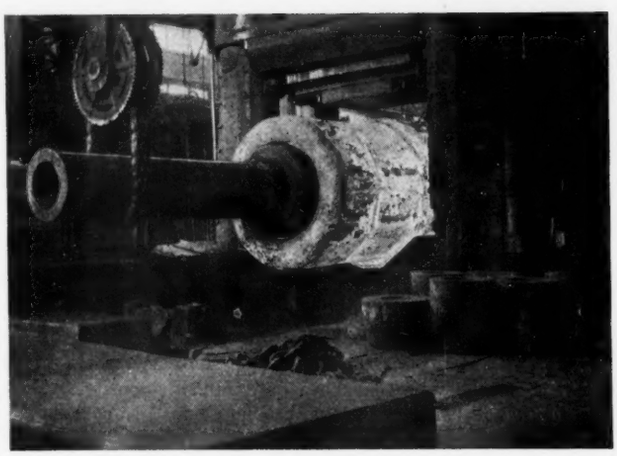


FIG. 5 BORING LONGITUDINAL HOLE THROUGH INGOT

Diameters up to $16^1/_2$ in. are bored from the solid. The outside diameters of the heads are babbitted and turned to size. Bores are opened by tooling to start the bit straight. Speeds vary so greatly with the character and condition of the metal and size of hole to be bored that it is practically impossible to give any definite figures covering them; $^1/_{64}$ in. feed is usually used. On mild annealed carbon steel 12-in. to 16-in. holes are bored at from $2^1/_2$ to 5 in. per hour. As with all the operations on these very heavy pieces, the rate at which the work can be done is determined by the rate at which the equipment used can be revolved, rather than by the machinability of the material.

The bored or trephined ingot is next hollow-forged on a series





FIGS. 6 AND 7 HOLLOW-FORGING INGOT ON A SERIES OF MANDRELS

of mandrels into the rough-forged cylinder shown in Figs. 6 and 7. During this process defects sometimes develop in the bore. These must be removed to prevent them from being worked into the job by further forging. The cylinder is allowed to cool and, depending on their size, the defects are either chipped or machined out. Where they are of such extent as to require machining they are a source of great annoyance, for it is impossible to anticipate and prepare for them, except in a general way—and the work must be done immediately and expeditiously.

The work is usually done with a heavy floor-type horizontal boring mill placed in the press plant for that purpose. This machine is of very heavy construction, has a $10^1/_4$-in.-diameter spindle, and is driven by a $37^1/_2$-hp. motor.

FIG. 8 DRUM AS FINALLY FORGED

FIG. 9 TAKING TEST BARS FROM DRUM

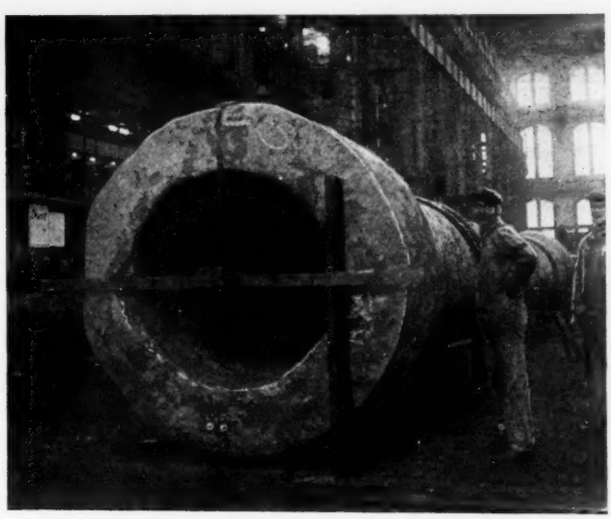


FIG. 10 LAYING OUT CYLINDER

When defects appear at or near the ends of the cylinder it is usually easy to mill them out with an inserted-tooth milling cutter. When further in the bore, however, boring heads on long bars are used with outboard bearings supported by spiders set in the bore of the cylinder.

In removing the defects the contour of the forging must be followed, removing as little metal as possible, and this may require a number of sets and runs.

Setting the spiders inside the cylinder is difficult work, and new equipment to suit the individual case must often be devised and completed rapidly.

FIG. 11 DRUM IN LATHE, SHOWING SPIDER

FIG. 12 TAKING DEVELOPING CUT ON OUTSIDE OF DRUM TO UNCOVER DEFECTS

The forging shown in Fig. 8 was finished into a closed-in Babcock & Wilcox high-pressure boiler drum 60 in. O.D. × 52 in. I.D. × 41 ft. 9 in. long, the weight of which was 106,920 lb. This forging weighed 180,880 lb., so that 73,960 lb. had to be machined off. Of this, 55,250 lb. was taken off during the first machining for closing in, and the remainder, 18,710 lb., during the final machining after closing in. The rough-forged dimensions of the drum allowed a 1-in. cut on the outside and a 1-in. cut in the bore. With the run-out and irregularities the actual cut amounts to from 1½ to 2 in.

From the forge the piece goes through a heat treatment which, of course, depends entirely on the grade of the material and the tests required.

The requirements of the Babcock & Wilcox cylinder shown were:

Carbon, per cent	0.45
Tensile strength, lb. per sq. in.	75,000
Yield point	½ T. S.
Elongation in 2 in., per cent	24
Reduction of area, per cent	38

The first job in machining is to take out test bars. The longitudinal bars are trephined out with a hollow drill. This is built up with a carbon-steel shank and a hollow high-speed drill body driven by a cross-key. Supplying cutting compound to the drill is very important and is effected through a stuffing box between the spindle of the machine and the drill. The drill shank is drilled longitudinally for this service. Bars are broken out by driving wedges into the end openings. Transverse tensile and bending test bars are drilled as shown in Fig. 9 and then broken out. It is to be noted that on the drum shown two settings were made to get two sets of test bars on each end of the cylinder.

Carbon-steel forgings are scaled with air hammers at spots close together for inspection purposes and to allow proper

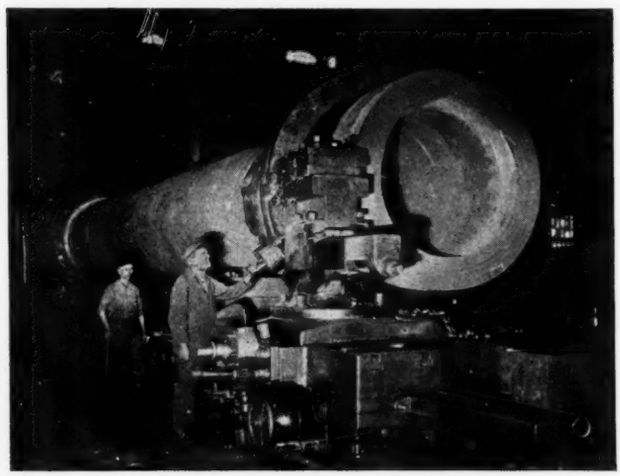


FIG. 13 CYLINDER IN LATHE FOR FINISHING SECOND END

layout of the work. Alloy cylinders are scaled all over for inspection and to facilitate machining.

The method employed in laying out is to stretch three parallel wires from end to end of the cylinder, one through the center and two along the outside at equal distances from the center wire (Fig. 10). By measuring from the wires to the wall of the cylinder the wires can be set to equalize the cut and make sure the job will finish both inside and outside. After the proper location for the wires has been determined, opposite spots on each end, both inside and out, are marked to show how they should run in the machine. The cylinder is given a quarter-turn and the operation repeated. This gives the run-out at four points on each end, enabling the machine operator to set the job.

The spider is set in the bore of the tailstock end (Fig. 11). This spider is a steel disk about 8 in. thick, with two radial rows of eight 2¼-in.-diameter pointed setscrews in its outside diameter. The points of the screws are hardened.[1] A hole through the disk allows it to be held in the bore on a porter bar while being set. The setscrews are tightened so as to set the outside of the disk according to the layout marks. The 60-deg. center is in a hardened plug, and is about 3½ in. in diameter. When these spiders were first put into use it was thought advisable to drive wedges between the disk and the cylinder, in addition to the setscrews, and to hold it from end movement with bolts from a strong back across the end of the cylinder. It was found that neither of these extra precautions is necessary. The job is set

in the lathe, the faceplate end being set in a pot chuck as previously described, the four marked points being made to run as marked when laid out.

The setting of the spider at the tailstock end is checked by the run of the spots on the outside.

The first operation is to take a developing cut off the outside diameter (Fig. 12). Should any defects be uncovered they must be chipped out and, if necessary, the cylinder thrown to favor the chip marks.

The developing cut is about a 1-in. cut with $^1/_4$ in. feed at about 18 ft. per min. Steady-rest spots are turned at both ends, and the tailstock end is sliced to length. The slicing tools are from $1^1/_4$ to $1^3/_8$ in. wide at the cutting edge, forged from 1-in. × 3-in. Midvale extra high-speed steel. They are well supported at the front end by a blade support.

Both welded-tip and solid turning tools of $1^3/_4$-in. × $2^3/_4$-in.

FIG. 14 18-IN.-DIAMETER BORING BAR

cross-section are used. For very heavy cutting the solid tools give better service, but the welded-tip tools are considerably cheaper. They are ground as regular round-nose roughing tools, with 8 deg. clearance, 8 deg. back rake, 12 deg. side rake, and no lip. The men are allowed to regrind their own tools to suit conditions, and get good results.

The cylinder is then taken out of the lathe, the spider removed, and the cylinder is turned around and reset in the machine. The tailstock end is now run in a steady rest on the spot previously turned (Fig. 13).

The carriage is left on the tailstock end outside the steady rest. The remainder of the job previously held in the chuck is turned and the second end is sliced, but when the job is close to length it is faced instead of sliced.

The next operation is to bore the cylinder. Formerly the boring was done with cutter heads as previously described, and it is still so done on smaller sizes, except that for an open bore a pair of high-speed-steel cutters are used, one on each side of the head, only sufficiently wide to cover the $2^1/_2$-in. to 3-in. wide cut, instead of the full-pointed cutter as in boring from the solid.

At present a bar is used on all large bores. This bar (Fig. 14)

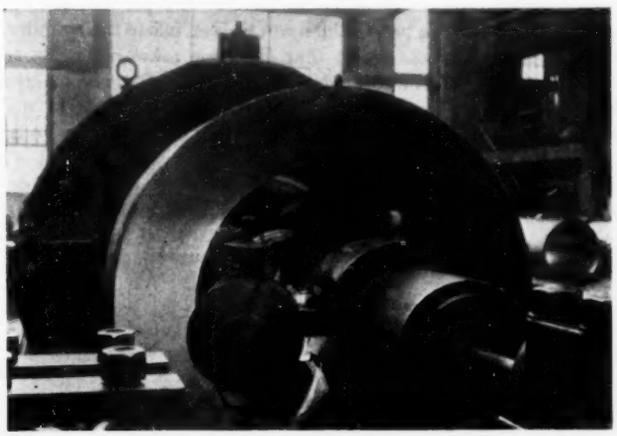


FIG. 15 BORING THE DRUM

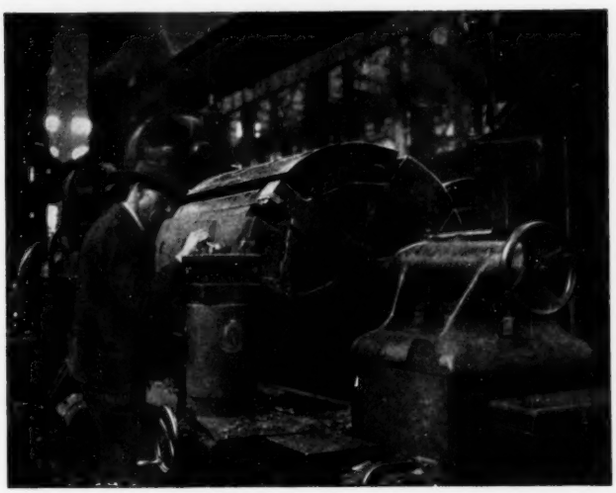


FIG. 16 WOOD-PACK BIT FOR FINISH BORING

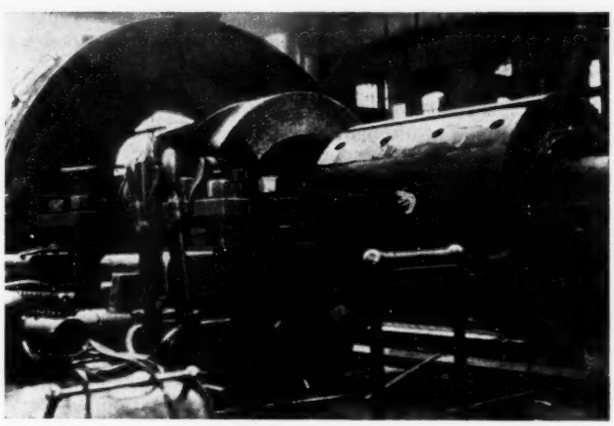


FIG. 17 ENTERING PACK BIT IN BORE

is 18 in. in diameter and has a feedscrew its entire length on the under side. The bar is stationary, the job being revolved. The cylinder is set in the lathe in the pot chuck and steady rest.

The bar is supported on the lathe center at the headstock, in a spider at the middle of the job, and in an outboard pedestal at the tailstock end (Fig. 15). The bearing in this pedestal has two flats which fit into recesses cut in the bar and prevent it from turning. The boring head, which can be seen inside the cylinder, has a number of tools set so that each one takes a portion of the cut. The feedscrew is driven from an extension to the lathe feedscrew through a sprocket chain. This type of stationary bar was chosen because it permits some turning to be done while the cylinder is being bored.

Depending on the cut, run-out, and character of the bore demanded, the feed will vary from $^1/_{16}$ in. to $^1/_8$ in. at about 18

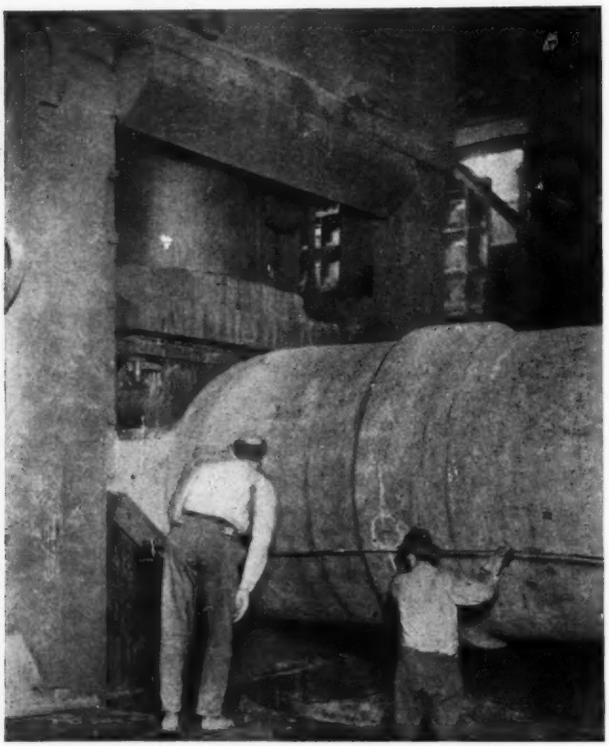


FIG. 18 CLOSING-IN END OF DRUM IN PRESS

ft. cutting speed, which on a 5-ft. I.D. drum will give from 4 to 8 in. per hour. The outside diameter is taken down to size at this time. Tolerances are $\begin{matrix}+\ ^1/_4\ \text{in.} \\ -0\end{matrix}$ on the outside diameter, and $\begin{matrix}-\ ^1/_4\ \text{in.} \\ +0\end{matrix}$ on the inside diameter. Top tolerances are adhered to where possible to give leeway should error occur.

As there is always some distortion in the body when cylinders are closed in, it is necessary that closed-in drums be finished outside as well as inside before that operation. This will leave the distortion in the finished job, but the required uniform wall thickness will be maintained. Cylinders out of round up to $^1/_2$ in. have been passed, and with a run-out up to $^{13}/_{16}$ in., equivalent to a bend of $^{13}/_{32}$ in.

Swells will be noticed on the ends of the open cylinder. These are left to furnish the metal for the closing-in operation.

On some drums a very smooth-finished bore is required. In such cases the rough bore made with the bar is left about $^1/_2$ in. small in diameter and a finish cut is taken with a wood-pack bit (Figs. 16 and 17).

When this is necessary the cylinder goes into a finish-boring lathe, after the steady-rest spots have been trued up. The bore is tooled out to size for a depth of from 14 to 16 in. to enter the pack bit (Fig. 17) and give it a start. The pack bits have blocks of oak or maple fitted to a cast-iron or steel center, and the wood is turned to suit the opened bore. They are left up to about 0.01 in. large—to allow for compression of the wood. High-speed or special finishing steel cutters are fitted and bolted to the front end of the center, and accurately set to size. This head is held in the front end of a boring bar which feeds it through the cylinder. Cutting oil is pumped on to the cutters and carries the chips out ahead of the bit. The oil must be free from water, as otherwise it would result in swelling the wood.

The footage per hour depends on the bore diameter. When it is possible to rotate the job fast enough, a cutting speed of about 15 ft. per min. is aimed at. A feed of about 0.030 in. is used. By this method a very smooth bore can be secured and sizes accurately held when necessary.

On these Babcock & Wilcox boiler drums the manholes are round and the joint is made on the inside. The finished heads therefore have to be inserted in the cylinder before it is closed in. To hold them in position and protect them from scaling during the forging, they are built into a brick wall in the center of the drum.

The cylinder now goes to the press and the ends are closed in (Fig. 18). During this operation galls sometimes form in the bore, and these must be machined out or they will make splits. This is done on the horizontal mill previously mentioned, sometimes by milling and sometimes by boring, as has been already described.

After the ends are completely closed in, the cylinder is again annealed. This is done to remove any possible strains set up during the closing-in operation. The drum then goes back to the machine shop for final finishing.

The first operation is to face one end and open the bore on one end sufficiently to let men enter. The boring is done with a tool bar. The brick wall is cleaned out, the heads being blocked in place with timber to hold them during the finishing.

The layout man again goes over the cylinder with wires to make sure it has been closed in to the proper length which is laid off on the outside. A tolerance of ± 2 in. is allowed.

The ends are then finished. The outside shape is allowed to vary reasonably to suit the inside contour, the important point being to maintain wall thickness. When the closed-in contour on the inside is plus beyond the permitted variation from the drawing, it must be machined. This machining is done in the lathe with a tool bar, the carriage being fed by hand. Sometimes the contour desired is laid out on the lathe shears and followed with a pointer on the carriage.

Holding the job in the chuck for finishing the first end is easy, but from the shape it will be noted that holding the finished end and driving from it to finish the second end is much more difficult. A centering plug which fits the bore of the cylinder is bolted to the faceplate of the lathe. The driving is done by a combination of two pot chucks bolted together back to back, one end extending over the straight part of the cylinder and holding the job, the other end being chucked.

As previously mentioned, drums go somewhat out of round and bend while being closed in. The ends must be turned to the large diameter of the previously finished portion so as to maintain wall thickness where the finishes meet. This leaves a small shoulder at the small diameter, which is dressed off by hand. The test holes for hydrostatic test are carefully laid out so that they will afterward machine out in the holes required for connections, etc.

As the final operation the drum is hydrostatically tested, and is then ready for shipment to the customer.

Economic Considerations in the Application of Modern Steam Turbines to Power Generation[1]

A Discussion Comprising Comments on Current Practice; Data on Costs, Floor Space, and Economic Performances; and Analyses of Reheating Problems and of the Economic Rating of Turbine Casings

By A. G. CHRISTIE,[2] BALTIMORE, MD.

An Analysis of Rating for a Turbine Casing

The following analysis of the relations of use factor, turbine costs, operating costs, and leaving losses to the economic rating of a given turbine casing is taken from a statement prepared by Mr. Francis Hodgkinson of the Westinghouse Electric and Manufacturing Company. A turbine casing was assumed for analysis which is normally rated at 30,000 kw., 1800 r.p.m., with 300 lb. per sq. in. gage, 620 deg. fahr., 29 in. vacuum, and with 57 sq. ft. of last-blade annulus. Its most efficient load at that rating and 100 per cent use factor is at 75 per cent of rated capacity or 22,500 kw. It was assumed that the high-pressure blade areas could be varied to suit the particular rating desired. Curve *A*, Fig. 11, indicates 100 per cent less leaving losses in percentage of total available heat drop under the stated steam conditions at the best point of efficiency for each rating. These leaving losses increase from 1.35 per cent at a best-point rating of 16,000 kw. to 114 per cent at a best-point rating of 54,000 kw. Curve *B* indicates the rate of increase of engine efficiency of the whole turbine except the low-pressure blades which results from the lower leakage losses and greater steam volumes with the increased flow at higher ratings. Curve *C*, a combination of curves *A* and *B*, is the engine efficiency of the whole turbine based on kilowatt output for the point of best efficiency at the various ratings, and shows the effect on efficiency of increasing the rating of such a turbine.

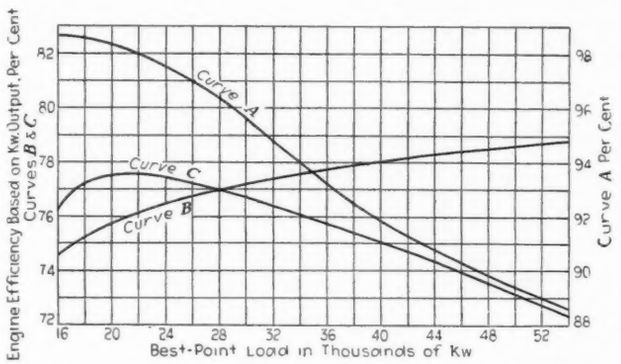


Fig. 11 Performance at Various Ratings of an 1800-R.p.m. Reaction Turbine-Generator With 57 Sq. Ft. of Last-Blade Annulus, With High-Pressure Blade Area Proportioned to Steam Flow

Operating conditions: 300 lb. per sq. in. gage, 620 deg. fahr., 29 in. vacuum
Curve *A* = 100%—% leaving loss
Curve *B* = engine efficiency based on kw. output exclusive of last rows
Curve *C* = engine efficiency based on kw. output of whole turbine.

Curve *E* in Fig. 12 shows the annual fixed charges per kilowatt at 17 per cent of the cost of the turbine-generator installed with foundations and piping. The unit costs in this analysis varied from $17.20 per kw. for a 30,000-kw. maximum continuous rated turbine-generator to $13.20 per kw. for the turbine-generator increased to 50,000 kw. maximum continuous rating. Curves *F* are annual operating costs per kilowatt of capacity for a variety of steam costs in dollars per 1000 lb., and of use factors expressed as decimals, the product of which is indicated by the quantity *K*. Thus $K = 0.20$ may indicate steam at $0.20 per 1000 lb. and a use factor of 100 per cent, or steam at $0.40 per 1000 lb. and a use factor of 50 per cent. In calculating curve *F* the steam consumption at each best-point load based on the efficiencies shown by curve *C*, Fig. 11, has been increased 2.5 per cent to allow for load fluctuations. These *F*-curves cover variations in use factors from 12.5 to 100 per cent, and in steam costs from $0.20 to $0.40 per 1000 lb.

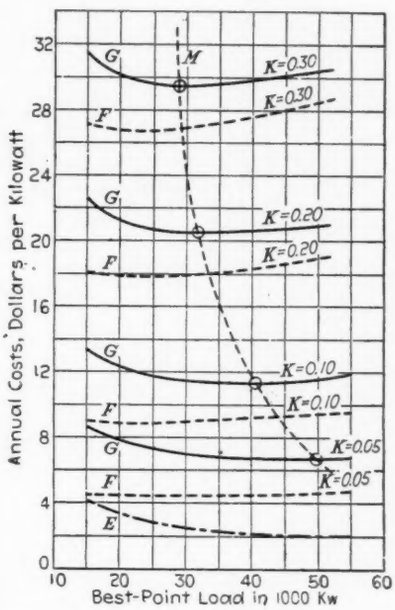


Fig. 12 Fixed Charges, Annual Operating Costs, and Total Annual Costs for Turbine-Generator of Fig. 11 With Varying Use Factors and Steam Costs Plotted Against Various Ratings. This Reaction Turbine Has a Last-Blade Annulus of 57 Sq. Ft.

(Curve *E*—Annual fixed charges in dollars per kw., based on 17 per cent of the first cost of turbine-generator installed, and including piping and foundations.
Curve *F*—Annual operating costs for various values of the product of use factor and costs per 1000 lb. of steam. Operating costs are based on the average load carried with an average steam consumption 2½ per cent higher than that calculated for the given load from data on curve *C*, Fig. 11. Hence annual operating costs = steam consumption in lb. per kw-hr. at given load as calculated from data on curve *C*, Fig. 11, × 1.025 × cost of steam per 1000 lb. × use factor × 8760 ÷ 1000.
Curve *G*—Total annual costs = curve *E* + curve *F* for each value of *K*.
Curve *M*—Loci of minimum values of *G* for various values of *K*.)

[1] Concluded from the July issue.

[2] Professor of Mechanical Engineering, The Johns Hopkins University. Mem. A.S.M.E.

Presented at the Second Plenary World Power Conference, Berlin, Germany, June 16–25, 1930.

Curves *G* show the total cost per kilowatt-year, which is the sum of the operating costs as shown by curves *F*, and the fixed charges as shown by curve *E* for various values of *K*. Curves *G* indicate that as *K* decreases, the point of highest commercial economy as measured by lowest total cost per kilowatt-year at the best-point rating, moves progressively to higher turbine capacities as shown by the intersection of line *M* with the *G*-curves. A stand-by turbine with a very low use factor and low fuel cost, resulting in a still lower value of *K* than shown in the curves, would have its point of lowest annual cost at still higher capacities than in these curves. The upper curve *G* for high-fuel coals and high use factors shows that under the premises assumed no material increase over standard rating can be made economically. The lowest curve *G*, where fuel costs and use factors are low, indicates that the best-point rating to give lowest total annual cost may be some 65 per cent above usual practice.

No regenerative feedwater heating was considered in calculating these curves. If regenerative heating were employed, the points of lowest total cost would move to the right. On the other hand, if lower rates than 17 per cent were used for fixed charges, these points would shift to the left.

A manufacturer, when furnished with specific operating data by the purchaser, can determine by such an analysis the rating of a casing that will give the lowest annual cost under the given conditions. A similar study of other sizes of casing will show which casing and rating will serve the customer's needs at lowest total cost per annum.

Two examples of such increased rating of casings will be described. The casing of the General Electric Company's turbines in the Gould Street Station of the Consolidated Gas, E. L. & P. Co., Baltimore, Md., was originally designed for maximum ratings of 20,000 kw. with 14 Rateau stages. One stage was omitted on the Gould Street units to allow space for bleeder connections, of which four were provided, and the blading on the remaining stages was redesigned. The modified turbine operates at 390 lb. per sq. in. gage, 700 deg. fahr., and 29 in. vacuum, and is proportioned to generate 36,000 kw. when all four stages of bleeding are in service. Its most efficient load is at 25,000 kw., which suits the particular use factors and fuel costs expected at this plant.

The annual use factor of the India Basin Station of the Great Western Power Company, San Francisco, Calif., will be unusually low due to the extraordinarily large water storage available for its interconnected hydroelectric power system with that of its affiliate, the San Joaquin Light & Power Company. The steam plant will act as a stand-by reserve, operating long hours per year at very light loads. Since hydroelectric energy is delivered to the city over a long transmission line and through cables 11 miles long under San Francisco Bay, the steam plant must be ready to pick up instantaneously the full load on the San Francisco distribution system in case of submarine cable trouble. Low first cost, even at a considerable sacrifice of operating efficiency at its maximum load, and rugged design were required by the small annual use factor and the severe operating conditions. In selecting a new turbine, a General Electric Company's casing of the size originally designed for 20,000 kw. capacity was modified to contain 1 Curtis and 8 Rateau stages as shown in

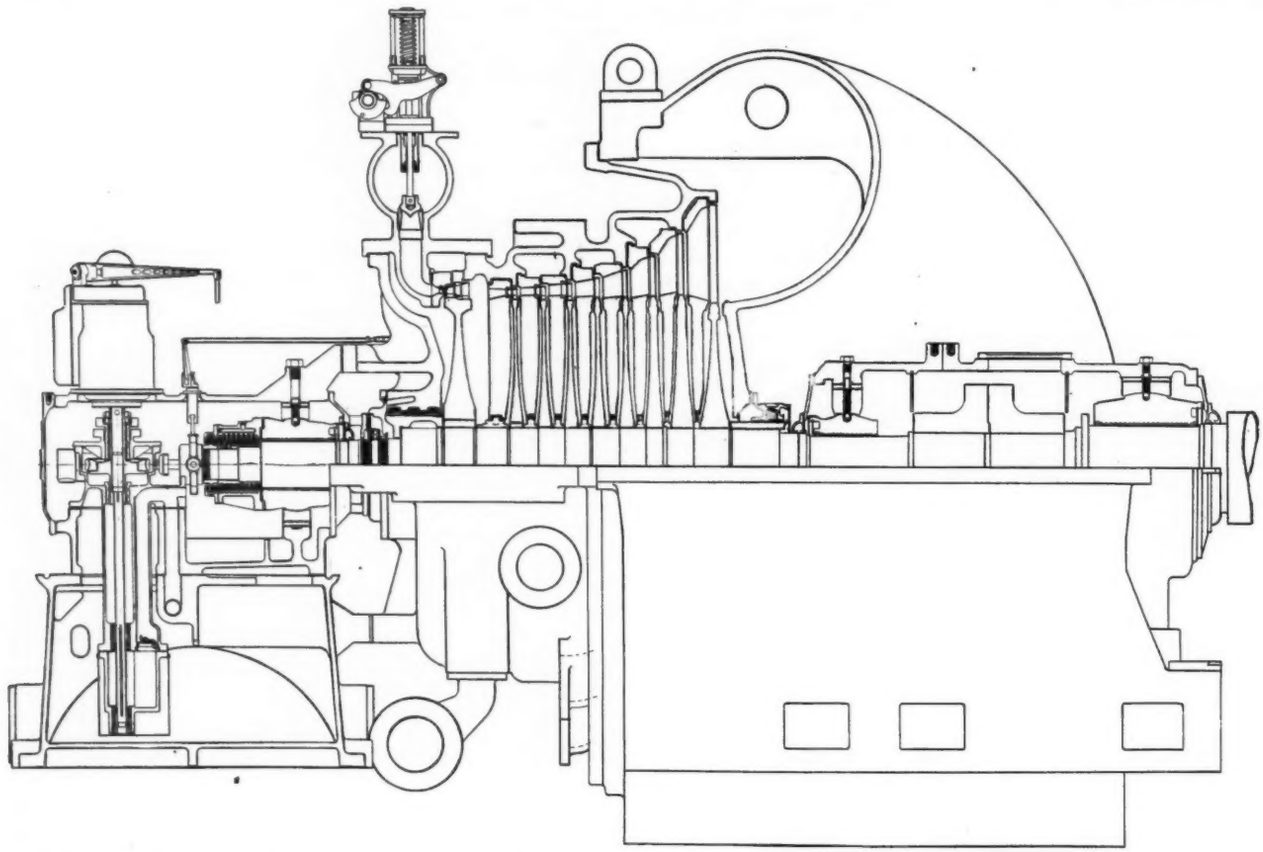


FIG. 13 CROSS-SECTION OF 35,000-KW. 1800-R.P.M. 9-STAGE STEAM TURBINE BUILT BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y., FOR THE INDIA BASIN STATION OF THE GREAT WESTERN POWER CO., SAN FRANCISCO, CALIF.
(Operating conditions: 350 lb. per sq. in. gage, 625 deg. fahr., 29 in. vacuum.)

Fig. 13 to give a maximum continuous rating of 35,000 kw. Secondary steam inlets were provided to enable the turbine to furnish full load, even should the initial steam pressure fall, when picking up sudden load, from 400 lb., 625 deg. fahr., to 235 lb. dry saturated. The most efficient load is 26,250 kw. at 400 lb., 625 deg. fahr., and 29 in. vacuum. The spinning turbine and its boiler plant pick up load instantaneously on an outage, since the unusually large boiler drums maintained at 400 lb. pressure serve as steam accumulators for the short interval while the oil burners are lighted.

TURBO-GENERATORS

Practically all large turbo-generators are now provided with water-cooling coils for the generator air which is continuously re-

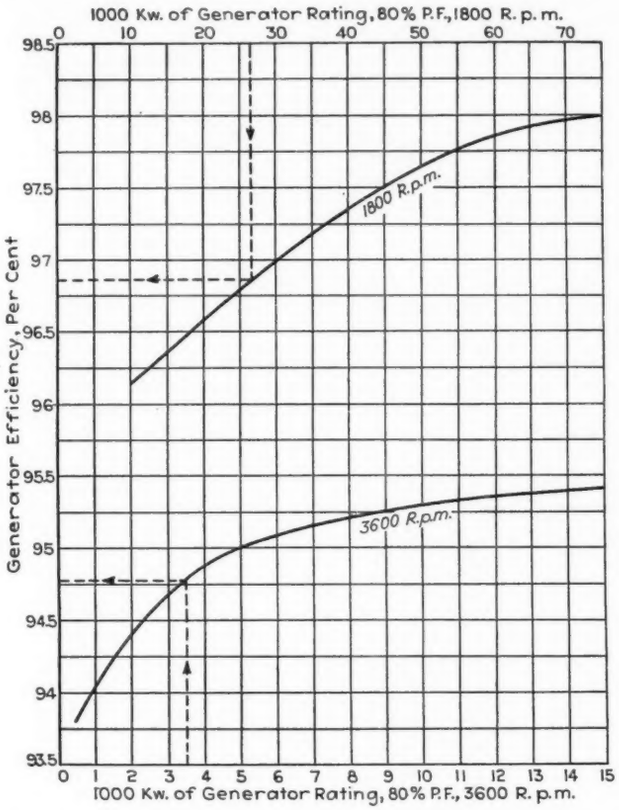


FIG. 14 AVERAGE AMERICAN TURBO-ALTERNATOR EFFICIENCIES FOR SIZES RANGING FROM 500 KW. AT 3600 R.P.M. TO 75,000 KW. AT 1800 R.P.M.

circulated. This has resulted in such economic gains as cleaner windings, lower operating temperatures, less fire risk, and a one-third reduction in outage.

There appears to be a trend in America toward the general adoption of 60 cycles as a standard frequency, with units operating at 3600, 1800, or 1200 r.p.m. There is, however, a large capacity of 25-cycle units in service operating at 1500 r.p.m.

Generator frames made of steel plates and bars joined by welding are now generally used in preference to cast iron. The steel frame is lighter in weight and costs less than cast iron, while ventilation passages can be provided at will. More rapid deliveries are possible as no time is needed for foundry work.

Hydrogen cooling of generators has been tried experimentally and appears to have advantages in keeping the windings cooler than with air. No central-station generators are using hydrogen cooling, although the possibilities of such operation are being studied.

Generator voltages of 22 kv. are in use in America and a 33-kv. generator is in operation in England. Generators wound for such high voltages cost more than those at 13 kv., but if the demands of local distribution can be furnished at generator voltage there is no added expense for step-up transformers and low-tension switch gear.

Practice differs in regard to the method of circulating air through generator windings. Some new forms of fan impellers integral with the rotor have been developed which improved air circulation. Motor-driven fans are placed outside of the generator frame on very large units. Some new propeller-type fans have been used for this purpose. While consuming less power than impellers on the generator shaft, some engineers object to a separately driven fan on the ground that another essential auxiliary has been added, the outage of which may necessitate a shutdown of the main unit.

The efficiencies of new turbo-generators have been increased, partly as a result of better distribution of the cooling air through the windings. Fig. 14 shows average efficiencies at rating for generators ranging in size from 500 kw. at 3600 r.p.m. to 75,000 kw. at 1800 r.p.m., with generator voltages from 400 volts for the smaller to 22 kv. for the larger sizes. The maximum deviation of generator efficiency for any size from the values of these curves should not exceed 1 per cent.

AMERICAN STEAM-TURBINE DEVELOPMENT

Condensing turbines up to 10,000 kw. at 3600 r.p.m. in a single casing are operating with an engine efficiency of 78 per cent at the turbine coupling. A special high-pressure turbine of 15,000 kw. at 3600 r.p.m. as shown in Fig. 15 (*a*), has been built with 85.6 per cent engine efficiency at the turbine coupling.

Turbines ranging from 10,000 to 75,000 kw. at 1800 r.p.m. are generally built as single-cylinder machines. About 75,000 kw., turbines are compounded with one or more double-flow low-pressure cylinders. Figs. 15 to 20 show recent American practice in the design of reaction turbines.

FOUNDATIONS

Structural-steel foundations are widely used for turbine-generators, and are frequently the cheapest to construct. They permit the location of bleeder heaters, generator air coolers, condensers, and other auxiliaries under the unit itself. Some engineers favor reinforced concrete or concrete-encased steel foundations. Vertical feedwater heaters placed at the side or ends of the main units make a satisfactory layout with concrete foundations. From another point of view considering relative weights, structural-steel foundations are often preferred when built upon piles, caissons, or a reinforced-concrete mat; if foundations are built upon rock, concrete may be used throughout.

II—SMALL STEAM TURBINES

Small steam turbines, condensing and non-condensing, as herein considered are those of less than 5000 kw. capacity. Such units are widely used in industrial plants, in pumping stations, and in central stations as auxiliary drives and house-service sets. A few units below 5000 kw. capacity are in use as main generators in the smaller central stations.

STEAM TURBINES FOR INDUSTRIAL PLANTS

Steam turbines are in competition with reciprocating engines in sizes up to 500 kw. Such competition with reciprocating engines of different styles with varying steam economy, led turbine builders to develop several types of turbines of varying efficiency and varying cost. It is now possible to purchase either turbines or engines of approximately the same steam economy for given operating conditions at about the same price. The efficiency

FIG. 15 10,000-KW., 3600-R.P.M. TURBINE BUILT BY WESTINGHOUSE ELEC. & MFG. CO., SOUTH PHILADELPHIA, PA.

(Operating conditions: 225 lb. per sq. in. gage, 550 deg. fahr., 28.5 in. vacuum. Steam consumption at 10,000 kw., 11.56 lb. per kw-hr. Generator efficiency, 98.2 per cent; engine efficiency at coupling, 77.5 per cent.)

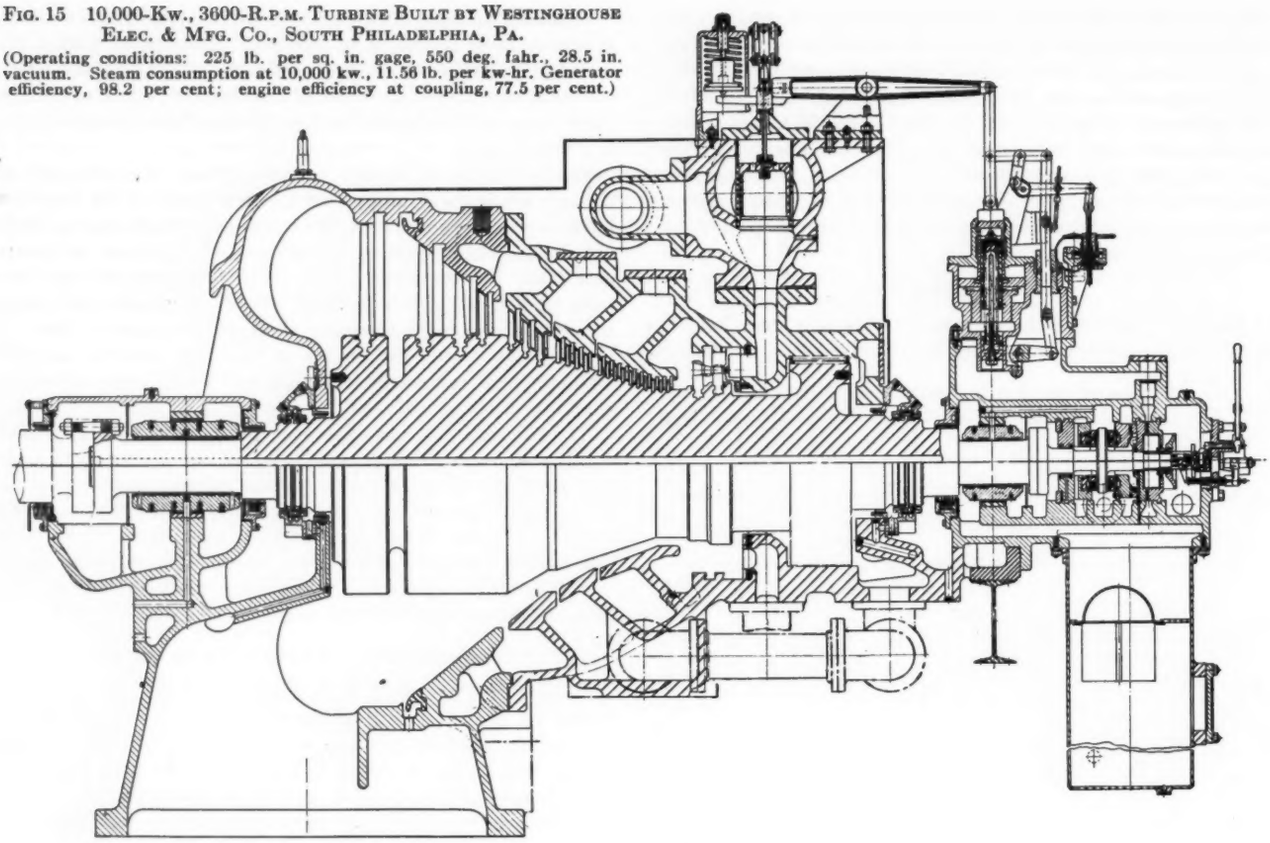
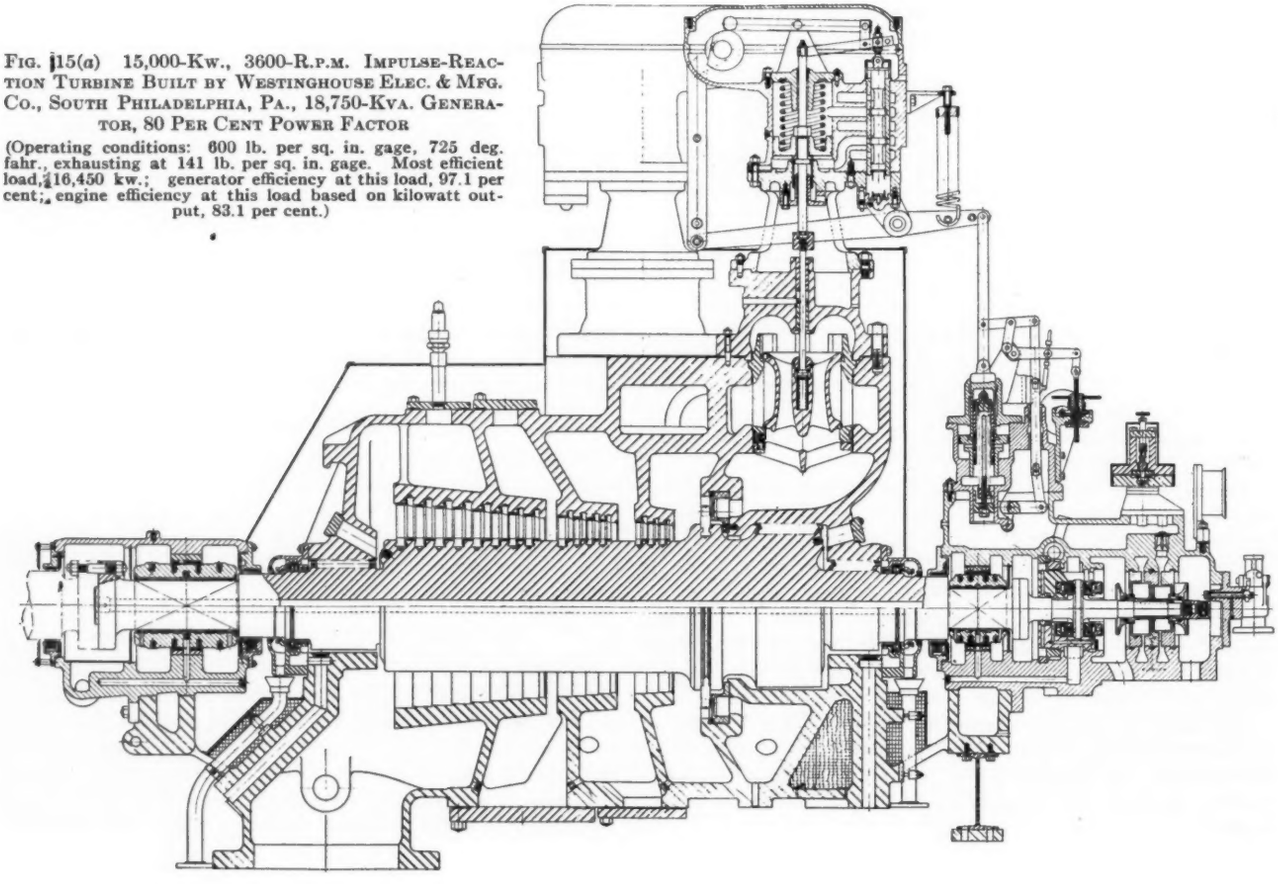


FIG. 15(a) 15,000-KW., 3600-R.P.M. IMPULSE-REACTION TURBINE BUILT BY WESTINGHOUSE ELEC. & MFG. CO., SOUTH PHILADELPHIA, PA., 18,750-KVA. GENERATOR, 80 PER CENT POWER FACTOR

(Operating conditions: 600 lb. per sq. in. gage, 725 deg. fahr., exhausting at 141 lb. per sq. in. gage. Most efficient load, 16,450 kw.; generator efficiency at this load, 97.1 per cent; engine efficiency at this load based on kilowatt output, 83.1 per cent.)



of the average small turbine can be increased over present standards by the development of carefully designed multi-stage units, operating at high speeds with mechanical reduction gearing. The efficiency of such gearing ranges from 96 to 99 per cent. Gear teeth have been developed so that wear is small on these parts when properly lubricated. Fig. 21 shows a typical condensing turbine for industrial plants.

Certain operating factors favor the economic use of turbines in many industrial plants. The freedom of the bled or exhaust steam from contamination with cylinder oil permits its use for industrial purposes or, when condensed, for boiler feed. Turbines require small floor space and are of moderate height, thus reducing engine-room volume. Erection costs are low. Attendance and maintenance are less than in the case of reciprocating engines. Any degree of superheat can be used when proper materials are furnished in the turbine for the given temperature.

Small turbines have been found preferable to either reciprocating engines or electric motors for use in dirty or damp places, and in plants where inflammable mixtures are present and no sparks can be allowed.

STEAM TURBINES FOR AUXILIARY DRIVES

Steam turbines are often used to drive auxiliaries in central stations. Their advantages for such use are: light weight, rugged construction, automatic operation, low maintenance, and economy in steam consumption in proportion to cost, which economy is maintained over many years.

The increasing use of electric motors for auxiliary drives in power plants will force the builders of turbines to develop more efficient small units for this service. There are many auxiliary drives around power stations where variable speed control is desirable. Such control, particularly with alternating-current motors, becomes expensive in comparison to the cost of turbines. If turbine efficiencies were improved, small units would be more widely used for such variable-speed drives since it is generally possible to utilize the exhaust steam of such units in the heat-balance system. At the present time, highest station economy generally results from the use of electric motors for auxiliary drive rather than of turbines, due to the high steam consumption of the latter.

Where great dependence is placed on a constant supply of auxiliary power, electric-motor drives may be less reliable than turbine drives. Frequently a spare turbine-driven auxiliary is provided for special emergencies. Another plan is the "duplex" drive with a motor at one end of the auxiliary shaft and a turbine at the other.

SELECTION OF INDUSTRIAL TURBINES

The type of small turbine to be selected for a given industrial service depends upon the demand it must supply, its efficiency, its use factor, and its first cost. The wide application of turbines to various services makes it impossible within the limits of this paper to specify the considerations affecting the selection of type in each case, though a few factors will be discussed.

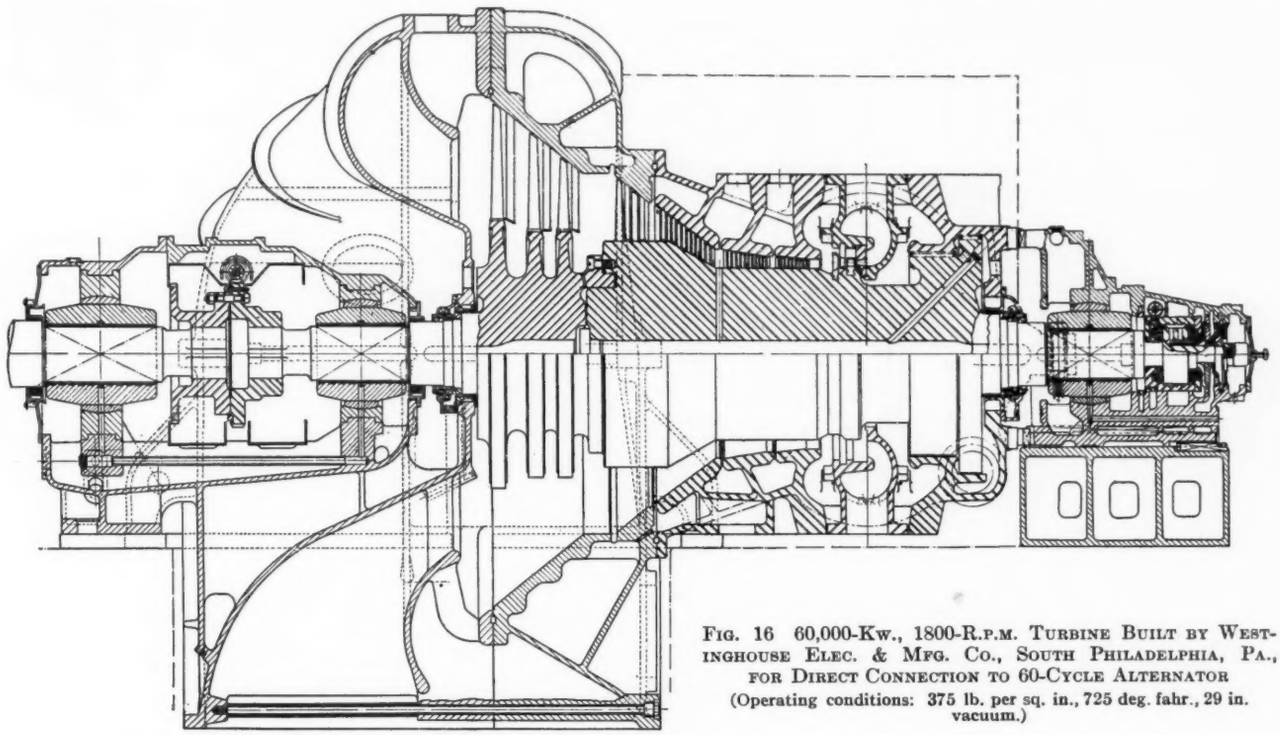


FIG. 16 60,000-KW., 1800-R.P.M. TURBINE BUILT BY WESTINGHOUSE ELEC. & MFG. CO., SOUTH PHILADELPHIA, PA., FOR DIRECT CONNECTION TO 60-CYCLE ALTERNATOR
(Operating conditions: 375 lb. per sq. in., 725 deg. fahr., 29 in. vacuum.)

As an example of a frequent type of plant problem, assume that the process requirements of an industrial plant demand the constant daily supply of large quantities of steam at some pressure above atmospheric. High-pressure boilers can be installed. Turbines can receive the high-pressure steam from the boiler and expand it to the needed process pressure. A portion of the heat made available for work from such an expansion would be converted by the turbine into electrical power. The greater portion of the heat in the steam would be exhausted to the process. Allowing for generator efficiency, mechanical losses in the turbine, and the usual boiler efficiency, electric energy is generated at a fuel expenditure of about 4500 B.t.u. per kw-hr. by this process steam. This represents roughly the consumption of one-third of a pound of coal per kilowatt-hour—a low figure. If this turbine can operate at a reasonably high use factor, the capital charges per kilowatt-hour will be low. In some cases the total cost of such power will be less than rates quoted for central-station service. Frequently the supply of cooling water for condensers is

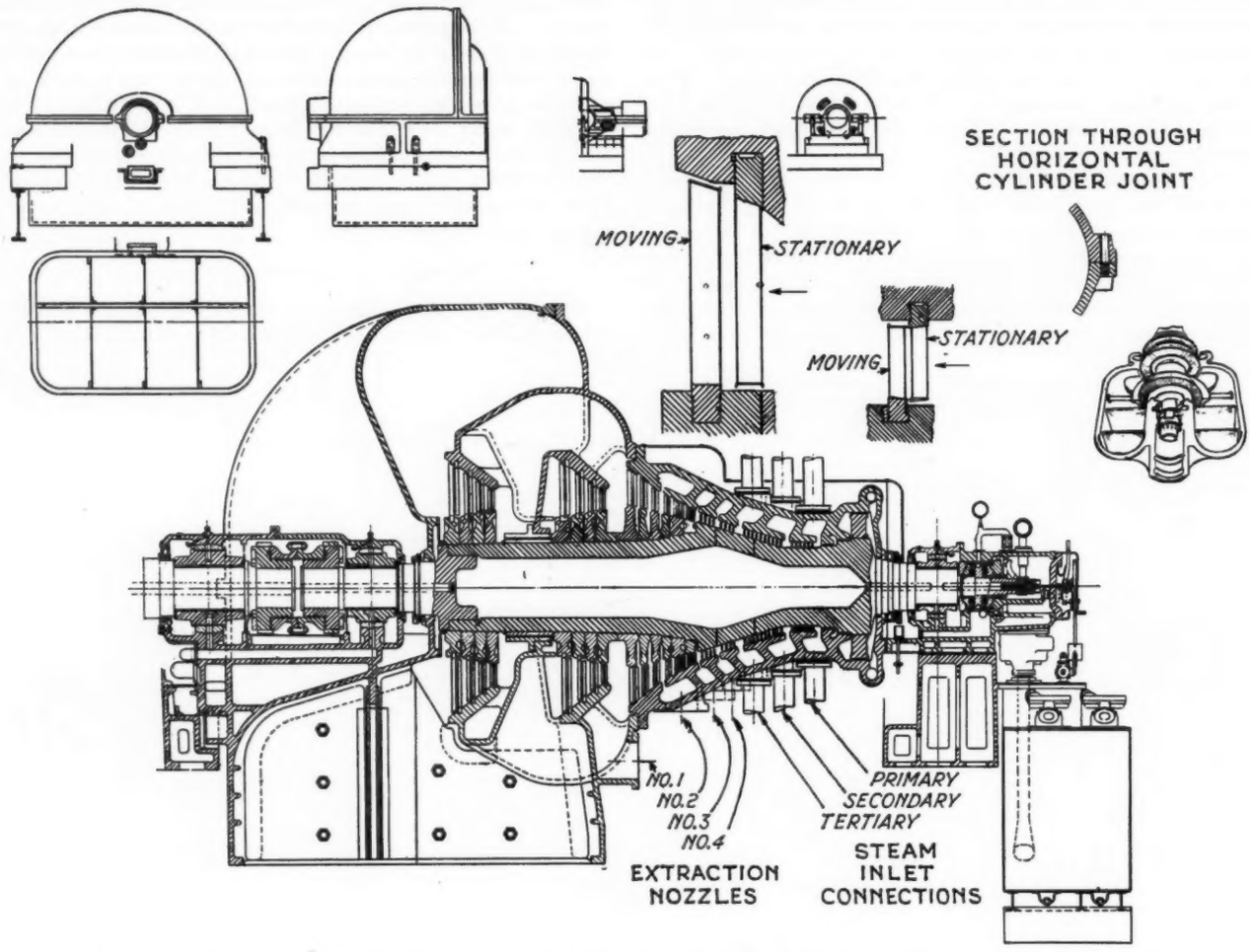
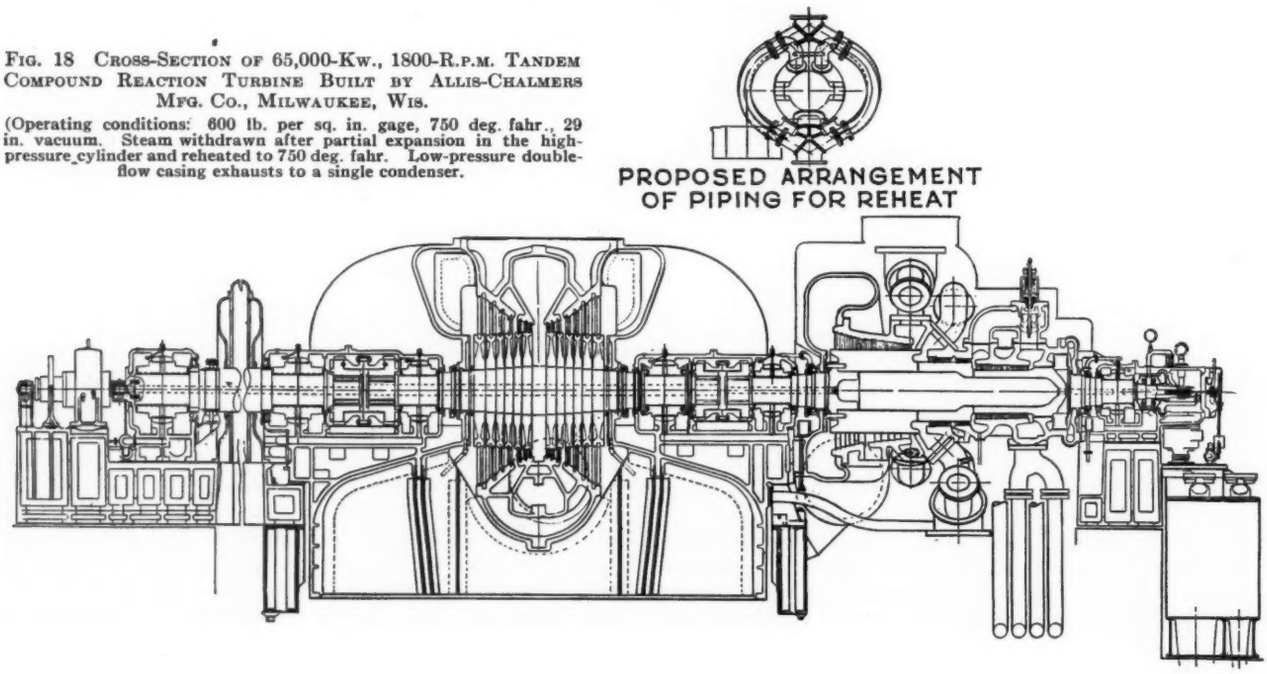


FIG. 17 CROSS-SECTION OF 60,000-KW. 1800-R.P.M. SINGLE-CYLINDER REACTION TURBINE BUILT BY ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS., WITH UNIDIRECTIONAL DOUBLE-FLOW EXHAUST

(Primary, secondary, and tertiary valves connected to cylinder through flexible U-bends. Unit to operate at pressures of 300 lb. and above, with temperatures up to 750 deg. fahr.)

FIG. 18 CROSS-SECTION OF 65,000-KW., 1800-R.P.M. TANDEM COMPOUND REACTION TURBINE BUILT BY ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

(Operating conditions: 600 lb. per sq. in. gage, 750 deg. fahr., 29 in. vacuum. Steam withdrawn after partial expansion in the high-pressure cylinder and reheated to 750 deg. fahr. Low-pressure double-flow casing exhausts to a single condenser.



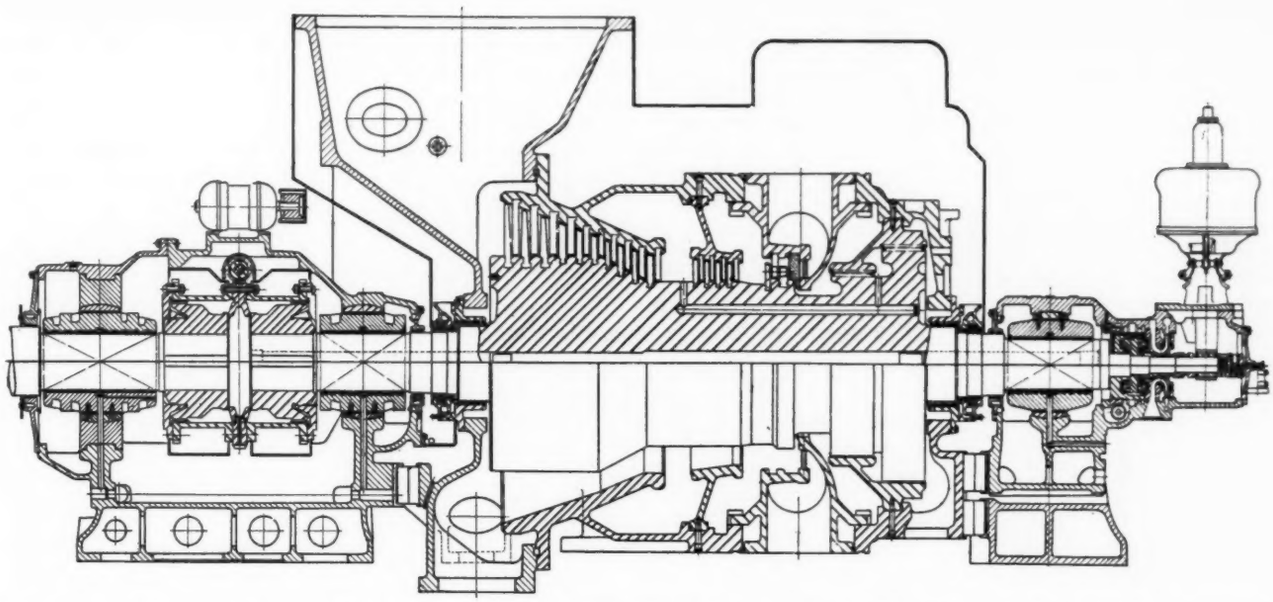


FIG. 19 HIGH-PRESSURE TURBINE OF THE HELL GATE NO. 9 UNIT BUILT BY WESTINGHOUSE ELEC. & MFG. CO., SOUTH PHILADELPHIA, PA., 1800 R.P.M. RATING OF COMPLETE UNIT, 165,000 KW.

Steam conditions: 265 lb. per sq. in. gage, 700 deg. fahr., 29 in. vacuum. One primary and one secondary valve admit steam to separate groups of nozzles on the impulse blading. On increasing loads two valves open admitting steam to reaction blading beyond the impulse element. Finally two valves admit steam beyond the first set of reaction blading.)

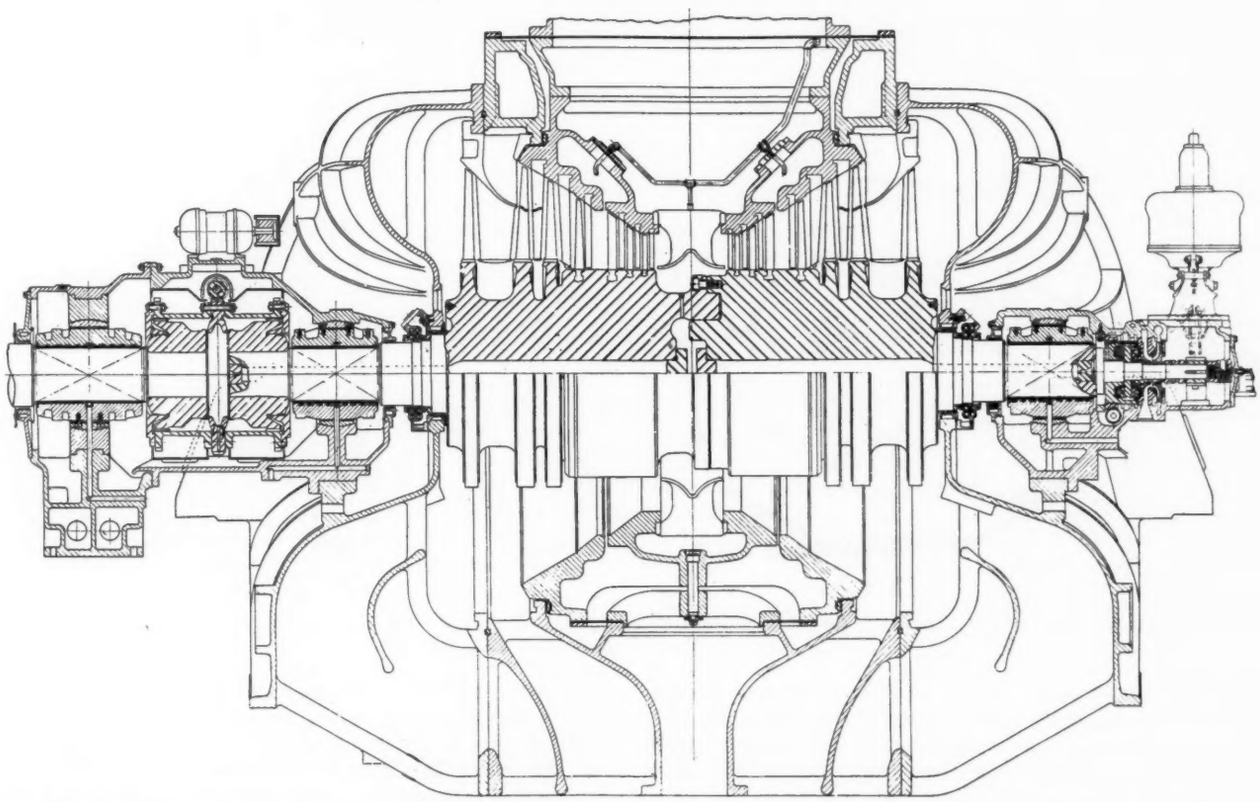


FIG. 20 LOW-PRESSURE TURBINE OF HELL GATE NO. 9 UNIT. 1800 R.P.M. RATING OF COMPLETE UNIT, 165,000 KW.

limited at an industrial plant. Since the amount of steam to be condensed per kilowatt-hour is less the higher the initial steam pressure, a larger electrical output can be secured from the available cooling water by utilizing high steam pressure. These considerations favor the installation of boilers for quite high pressure in an industrial plant. Should such low-cost energy from these high-pressure turbines not be required by the industry itself, it may be possible to sell this power at satisfactory rates to a public-utility distribution system.

Many factors must be considered before deciding whether to

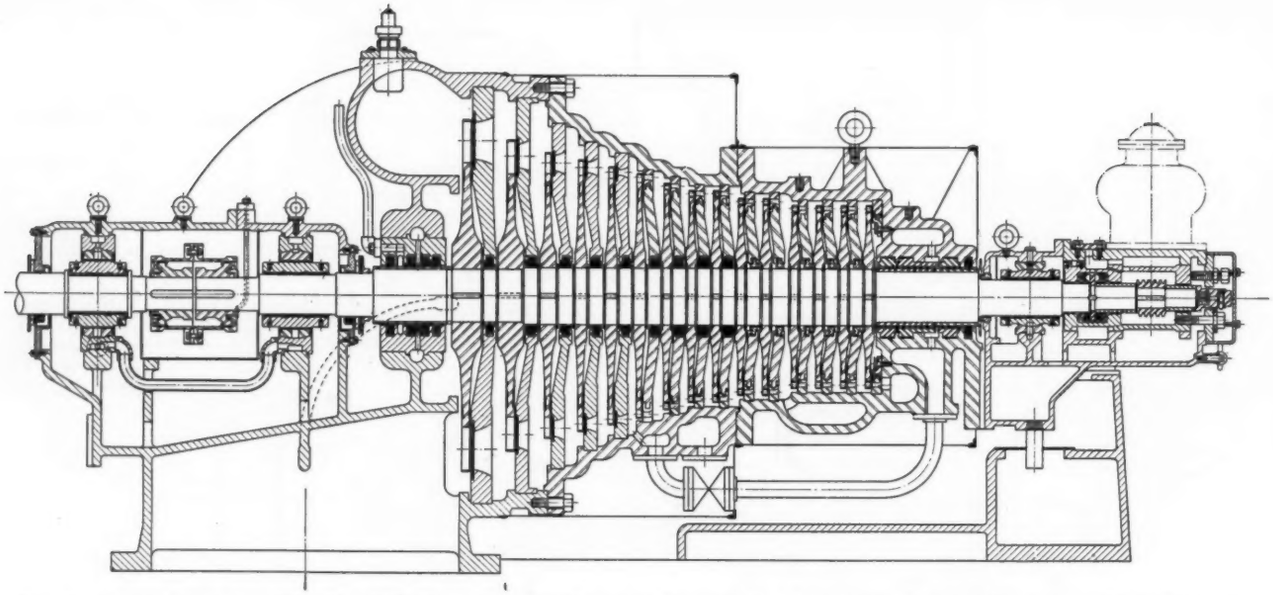


FIG. 21 CROSS-SECTION OF 1500-KW. 3600-R.P.M. TURBINE BUILT BY ELLIOTT CO., JEANNETTE, PA., FOR INDUSTRIAL-PLANT SERVICE

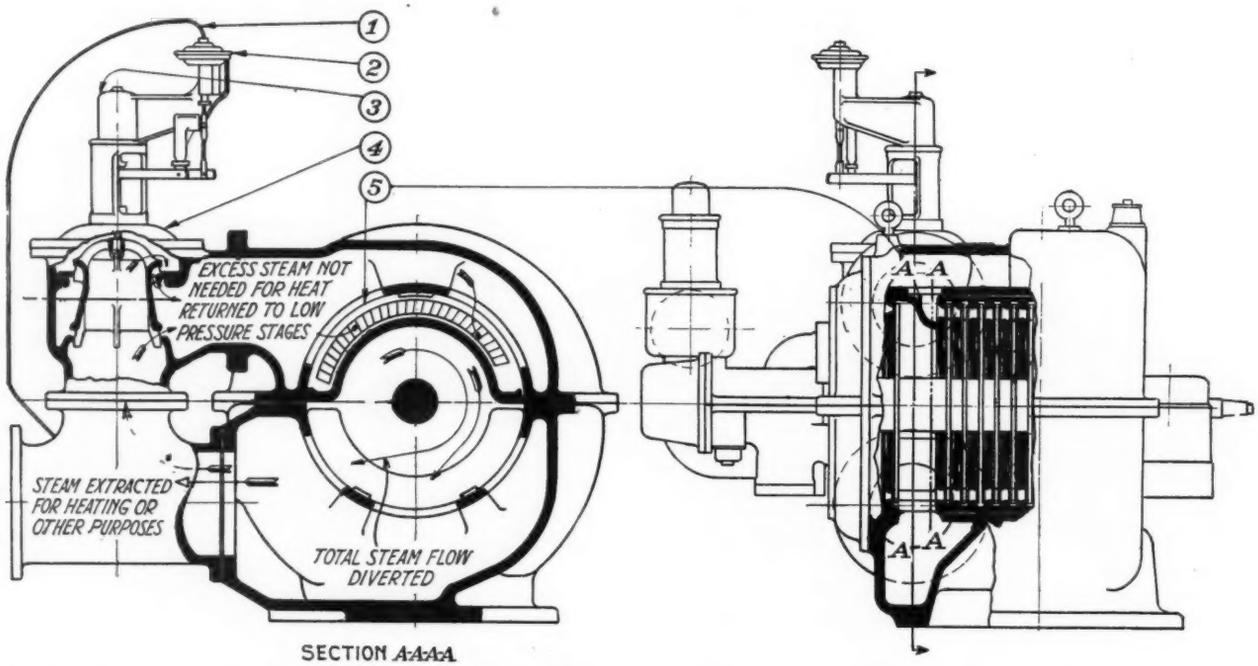


FIG. 22 TYPICAL BLEEDER TURBINE BUILT BY TERRY STEAM TURBINE CO., HARTFORD, CONN., FOR AUTOMATIC REGULATION OF CONSTANT PRESSURE IN BLEEDER PIPE

use central-station energy or to construct an industrial power plant. One must know the heat balance of the plant; the pressure at which steam must be furnished to the various processes; the quantities of exhaust and process steam required in the plant; the nature of the processes in which the exhaust or bled steam will be utilized; the character and fluctuations in the process demands; the possibilities of steam storage; whether or not the condensate can be returned to the boilers; the character of the power load and the relation of its demands to those for process steam; the availability of cooling water if condensers are to be used; the costs of fuel and of labor; total operating hours per year; the seasonal variations of the industry; and the cost of central-station power. The engineer must then analyze these data to determine which service should be adopted.

Either pure condensate or distilled water from evaporators should be used as feedwater for high-pressure boilers operating at high rates of evaporation. If the industrial process is such that no condensate is returned to the boilers, the cost of distillation of the feed by evaporators may become prohibitive. Pure boiler feed is secured in some plants by exhausting from a high-pressure turbine into reboilers which furnish the process with steam from raw water while the pure condensate from the reboiler is returned as feedwater to the main boilers. These so-called reboilers are virtually large evaporators.

Low-pressure turbines have been used where there is a large supply of low-pressure steam available from plant processes or machinery, such as the exhausts from steam hammers and forging presses, or from rolling-mill engines. Steam accumulators are needed if the supply of steam is fluctuating. Mixed-pressure turbines may also be used with fluctuating supplies of exhaust steam, and are now generally installed in place of low-pressure units.

Two types of bleeder turbines are used in American industrial plants. In one type a constant pressure is automatically maintained in the bleeder pipe to the process by a control valve, while in the second type the pressure in the bleeder connection fluc-

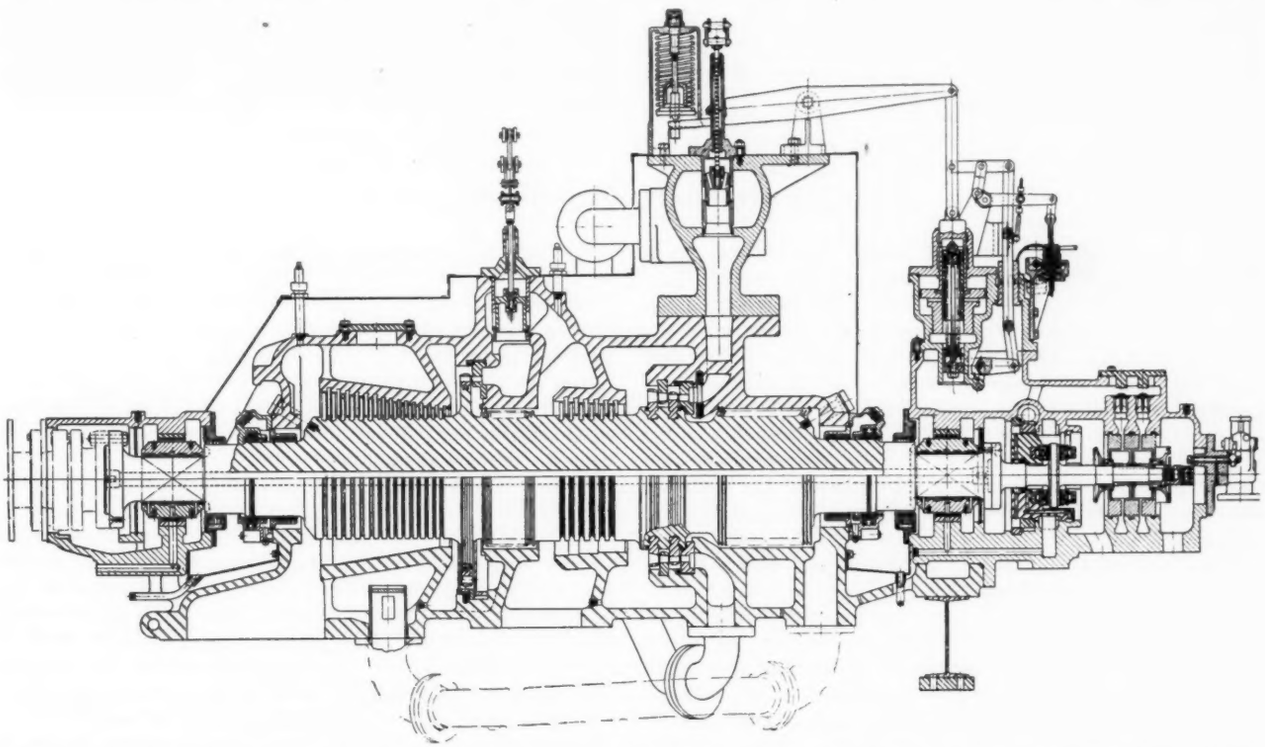


FIG. 23 4500-KW. 3600-R.P.M. AUTOMATIC BLEEDER TURBINE BUILT BY WESTINGHOUSE ELEC. & MFG. CO., SOUTH PHILADELPHIA, PA., FOR CONNECTION THROUGH REDUCTION GEARING TO A 25-CYCLE 5000-KVA. 80 PER CENT POWER FACTOR 750-R.P.M. GENERATOR (Steam conditions (initial): 550 lb. per sq. in. gage, 700 deg. fahr.; bleeder pressure, 180 lb. per sq. in. gage; exhaust pressure, 20 lb. per sq. in. gage.)

tuates with the load. The section of the turbine to the bleeder point in the first type consists essentially of a high-pressure turbine operating under constant-pressure conditions; the remainder beyond the automatic pressure-control valve serves as a low-pressure turbine with varying inlet pressure. Turbines may be bled at several points to provide different steam pressures as needed.

Various devices are used in the first type to maintain the constant pressure at the bleeder point. When the bleeder pressure is low, grid valves are frequently built into the turbine diaphragm. If the steam must be bled at high pressures, some type of automatic balanced valve placed outside the casing may be used. In still other cases nozzle control on the low-pressure section, either in the form of separately controlled valves or of needle valves in the individual nozzles, provides a more efficient use of the steam in the low-pressure stages. Figs. 22 and 23 show two types of American bleeder turbines and the method of bleeder control employed in each case.

The economic selection of the most suitable bleeder turbine is a matter involving much study. In general, every industrial plant is a complete problem in itself, and each turbine should be designed to meet the demands of that individual plant in the most economical manner. This results in increased first cost on account of the engineering studies and shop changes involved. On the other hand, the fuel savings or increased power output resulting from such careful studies may quickly repay this added cost.

The calculation of the performance of bleeder turbines is somewhat complicated. The manufacturer should be informed of the general plant conditions such as the initial, the bleeder, and the exhaust pressures, the amount of steam to be bled at various loads on the turbine, and the cooling-water temperatures. The manufacturer's offer should then contain a performance diagram for the proposed turbine, from which the quantities of steam involved at the various loads can be determined. The manufacturer should also furnish data on the total heat of the steam at the bleeder point under specified load conditions.

ECONOMIC PRESSURES AND TEMPERATURES IN INDUSTRIAL PLANTS

There is no unanimity of opinion in regard to the steam pressures to be used in industrial plants. On account of lower use factors these pressures have generally been below contemporary practice in central stations. The high fuel prices prevailing since the war, and the realization that economies may be secured through the use of high steam pressures with high-pressure or bleeder turbines, are changing industrial-plant design. High steam pressures will be used in many such plants in the future.

Steam temperatures have been kept low in these plants, frequently due to indifferent furnace operation which resulted in great variations in superheat. Better fuel-burning equipment together with the increasing use of automatic boiler control have done much to insure steady steam temperatures at the turbine

throttle. The advantages of high superheat in small turbines are recognized, and steam temperatures will be increased in new industrial power plants.

III—CONCLUSIONS

Certain of the economic considerations involved in the applications of modern steam turbines to power generation have been outlined in the preceding paragraphs. The engineer's ideal in every case would be the selection of the one best turbine for every job. However, as indicated above, such independent variables as size, use factor, fuel cost, first cost, and fixed charges, produce a large number of combinations of which several may be equally efficient when measured by the standard of "total cost per kilowatt-hour of output." This leads to differences in opinions and in practice and to variations in design. Meanwhile the field of application of steam turbines in both industrial-power and central-station services has steadily increased.

It is not within the province of an engineer to predict future developments in power generation. However, the place for steam turbines in the generation of power seems to be steadily expanding. The more extended use of water power will necessitate the construction of auxiliary steam-turbine plants for operation in low-water periods and during dry seasons in order to utilize the available water most economically. In some cases water power, depending largely or wholly upon pondage, carries the peak loads, while steam-turbine plants furnish the long-hour service loads.

Looking into the immediate future, there does not appear to be any new machine or process that is now under development for producing power which may be expected to displace the steam turbine. While one cannot foretell when new sources of energy may be discovered, information now at hand indicates that during coming years one must continue to use steam turbines to supply the major power demands of the world.

Engineering Leadership

THE ENGINEER'S mastery of energy and material things must go on. He cannot pause nor shirk his responsibility, but through the character of his leadership, he has brought upon himself the responsibility for our present social order. He has brought about our industrial civilization and he must accept leadership which will keep for mankind the benefits which it gives and contribute to the suppression of the evils which have accompanied those benefits.

To insure this steady march of progress toward civilization requires industrial statesmanship of the highest order. While the world cannot demand, nor can the profession furnish, more than a reasonable proportion of executive leadership in industry, yet the engineer's analytical method of thinking and his passion for truth can and will have a great influence on all industrial leadership. Last year Dean Kimball gave a courageous and convincing reply to the critics of this technological age. Yet no one knows better than the engineer, the weaknesses of structure in industry and the deterrent influence of these weaknesses on our national progress and prosperity. He knows that the fundamental difficulty in industry today is lack of coordination. The truth of this is best demonstrated by the undoubted success of industries which are well coordinated within themselves and in their relations with others in the same field of production.

The reason that this is peculiarly a problem within the responsibility of engineering leadership is that engineers, through the development of technological processes, have solved the production problem. Productive capacity in this country today actually exceeds the capacity for consumption. Coordination which will relate supply to demand is the imperative problem which calls for solution. The problems of distribution are still far from correct solution. No one can deny that the wide spread between cost at point of production and price to the ultimate consumer is altogether too wide. This problem, of course, involves efficient studies of economy in the whole transportation industry, but it involves more than that in the determination of the points from which distribution should be made.

Another condition which is crying out for relief is that of unemployment. The engineer, through high leadership in technological fields, cannot deny his measure of responsibility for creating this condition. The term "technological unemployment" symbolizes that responsibility. Here is the darkest shadow thrown across the picture of our national prosperity and most obscure are the means of bringing light where that shadow falls. It is another challenge to engineering leadership.

Throughout this meeting we shall be considering the subject of the teacher and his work. Engineering leadership is born in engineering education. A great responsibility rests today upon you as teachers of engineering. You are the real leaders in engineering, for you will equip the young engineer with the elements of knowledge which will best enable him to take up his life's work and carry it forward with the confidence you have given him in his own intellectual development. Industry has come to value in the graduate more than all else, a firm background of fundamental science and engineering principles, realizing that it is the responsibility of industry itself to train the young men in its own specializations. One demonstration, of course, of engineering leadership in education, is the wisdom shown in the structure of the curriculum. Speaking for the moment from the viewpoint of industry, we who make a conscious effort to employ the engineering graduate, secure him, we hope, for future leadership. We are not employing him for the small job that is available today. We want him, when coming to us, to attack each problem in a thoughtful way, to relate the small job first assigned to him to those of his associates and of his superiors, so that he will grow in ever-broadening comprehension. Then, when he comes to that period ten or fifteen years hence, when he has passed through the lower supervisory levels in staff or operations and emerged into an executive position, he will know how to respond to the demands imposed on him and be able to solve the serious problems which confront him. With your help and his subsequent experience, he will then have prepared himself for the higher realms of engineering leadership, yes, of industrial statesmanship.

While you are responsible for his earlier development, you will help him to develop character; you will give him fundamental knowledge; you will teach him how to get along with his fellows, and give him a realization that the greatest problem which he will face in his life's work is that of human relationships; if he has a bent for scientific research, you will encourage it, guide him and direct him in graduate work. From you he will get the realization of the value of truth and apply those values in engineering method of thought. Through you he can face the world with trained intelligence. Finally, with your constantly improving standards of teaching, you are developing within the student, a true culture.—From the Presidential Address, delivered at the Montreal Meeting, June 26 to 28, 1930, of the Society for the Promotion of Engineering Education, by R. I. Rees, Asst. Vice-Pres., Am. Tel. & Tel. Co., New York, N. Y. Mem. A.S.M.E.

The N.A.C.A. Conference at Langley Field

By ALEXANDER KLEMIN,[1] NEW YORK, N. Y.

THE National Advisory Committee for Aeronautics Conference at Langley Field, Virginia, held on May 17, was the third of this annual series. These conferences, invariably well attended, serve many purposes, the most important being that of acquainting the aeronautical industry with the important research work being carried on by the N.A.C.A. and of placing before the Committee the problems whose solution the industry requires.

As in previous conferences the meeting brought together representatives of various government departments and executives and engineers of important aviation companies. Among the many eminent personalities present may be mentioned F. Trubee Davison, Assistant Secretary of War, Maj.-Gen. James E. Fechet, Chief of the Army Air Corps; Brig.-Gen. Benjamin B. Foulois, Chief of Wright Field; Igor Sikorsky, of the Sikorsky Airplane Manuturing Company; T. P. Wright, Chief Engineer of the Curtiss Aeroplane & Motor Corporation; William B. Mayo, Chief Engineer of the Ford Motor Car Co.; Grover Loening, Temple Joyce, Henry Berliner, and William H. Miller, of the Berliner-Joyce Aircraft Corporation; Lieut. H. Sutton and Sherman M. Fairchild, of the Aviation Corporation; Seth Low, President of Roosevelt Field; C. H. Colvin, of the Pioneer Instrument Company; Commdr. Bruce G. Leighton, Sales Manager of the Wright Aeronautical Corporation; R. H. Fleet, of Consolidated Aircraft; R. N. Hartzell and Paul Charavay, of the Hartzell Propeller Co.; F. H. Russell, of the Curtiss Aeroplane & Motor Corporation; Lassiter C. Millburn, Chief Engineer of the Glenn L. Martin Co.; William B. Stout; H. V. Thaden, Chief Engineer of Pittsburgh Metal Airplanes; William P. MacCracken, Jr., of the New York, Rio, and Buenos Aires Airline; R. Chilton, Consulting Engineer, Wright Aeronautical Corporation; Mac Short; Luther K. Bell, of the Aeronautical Chamber of Commerce, and many other representative men of the industry.

New Equipment

The splendid laboratories of the Committee are in constant process of development and improvement, but deserve no special mention at this time. The projects for new equipment are of great interest and importance, however.

In the science of aerodynamics the wind tunnel has played a tremendous rôle. From the point of view of the study of efficiency and interference between parts, the conventional atmospheric wind tunnel has been handicapped by the presence of scale effects. Even the largest atmospheric wind tunnels have a Reynolds number, or a product of linear dimension times speed, which falls far short of the full-scale airplane. Aerodynamic predictions based on wind-tunnel experiments are based on the law that forces vary as the area and the square of the speed. In drag, particularly, skin friction plays a part and skin friction varies somewhat less rapidly than the area, and approximately as $V^{1.85}$. Therefore errors of varying magnitude are introduced in scaling up to full size. The Committee has consistently and rightly regarded the study of full-scale corrections as one of its major problems.

One line of attack was in the construction of a compressed-air tunnel. The Reynolds number is given by the expression VL/ν, where ν is the kinematic viscosity. Since kinematic viscosity varies inversely as the density of air, compressed air has a smaller kinematic viscosity than air at atmospheric pressure. Accordingly in the compressed-air tunnel, where pressures of 20 atmospheres are available, the kinematic viscosity is reduced to one-twentieth of its value in the atmospheric tunnel and the Reynolds number is multiplied by twenty accordingly. Thus in the compressed-air tunnel, full-scale phenomena are reproduced more or less accurately, even though engineers are somewhat divided as to the complete validity of the method.

Even the compressed-air tunnel is not a perfect instrument of research since it is impossible in this tunnel (which has a working-section diameter of 5 ft.) to place the very large models needed for the study of interference between parts, the study of full-sized propellers, their effects on the rest of the airplane, etc. The final solution is the utilization of a tunnel large enough for a full-sized airplane to be placed in its working section. The Committee as a first step in this direction constructed a 2000-hp. wind tunnel having an open-throat working section 20 ft. in diameter. Many highly interesting experiments have been performed in this 20-ft. wind tunnel. The Committee has now under contract an even more ambitious wind tunnel. This is to have a rectangular working cross-section of 30 × 60 ft., with the longer dimension horizontal. It will thus be possible to place a full-sized airplane in the tunnel in normal flying position. The tunnel is to be of the return type, in which the air circulates round and round. The plan form of the tunnel is also rectangular, with the air guided at the corners by carefully designed vanes or guides. Two large propellers, each 35½ ft. in diameter, will be used to create the air stream. They will be driven by a 6000-hp. electric motor and are expected to provide a speed of 120 miles per hour at the working section of the tunnel. The tunnel is to be housed in a large building 434 × 222 ft. in plan. It is understood that the cost of the new tunnel will be close to one million dollars.

A new atmospheric tunnel has been completed in which the air flow is vertical. In this tunnel it is possible to give special attention to autorotation, the model being suspended so as to rotate substantially about a vertical axis. Two other tunnels of this type are to be constructed, and many useful data are expected to clear up such phenomena as autorotation and spinning.

The Committee with exemplary courage has also tackled the problem of hydrodynamic research pertaining to aeronautics. In the whole of the United States but two towing basins are available, both kept busily employed by the problems of surface vessels. The new towing basin constructed by the N.A.C.A. is to be exclusively devoted to flying-boat and seaplane problems. The new water channel will be the largest in the world, with a length of 2060 ft., a width of 25 ft., and a depth of 12 ft. Full-sized pontoons can be towed in this basin at a speed of 60 miles per hour. Flying-boat hulls of moderate size can also be towed in such a channel. The channel is so designed

[1] Daniel Guggenheim School of Aeronautics, New York University, New York, N. Y. Assoc-Mem. A.S.M.E. For two years Professor Klemin was in charge of the department of aeronautics at the Massachusetts Institute of Technology. In 1917 he took charge of the aeronautic research section of the airplane engineering division of the Bureau of Aircraft Production, McCook Field, Dayton, Ohio. He has contributed widely to the technical press on matters concerning aeronautics.

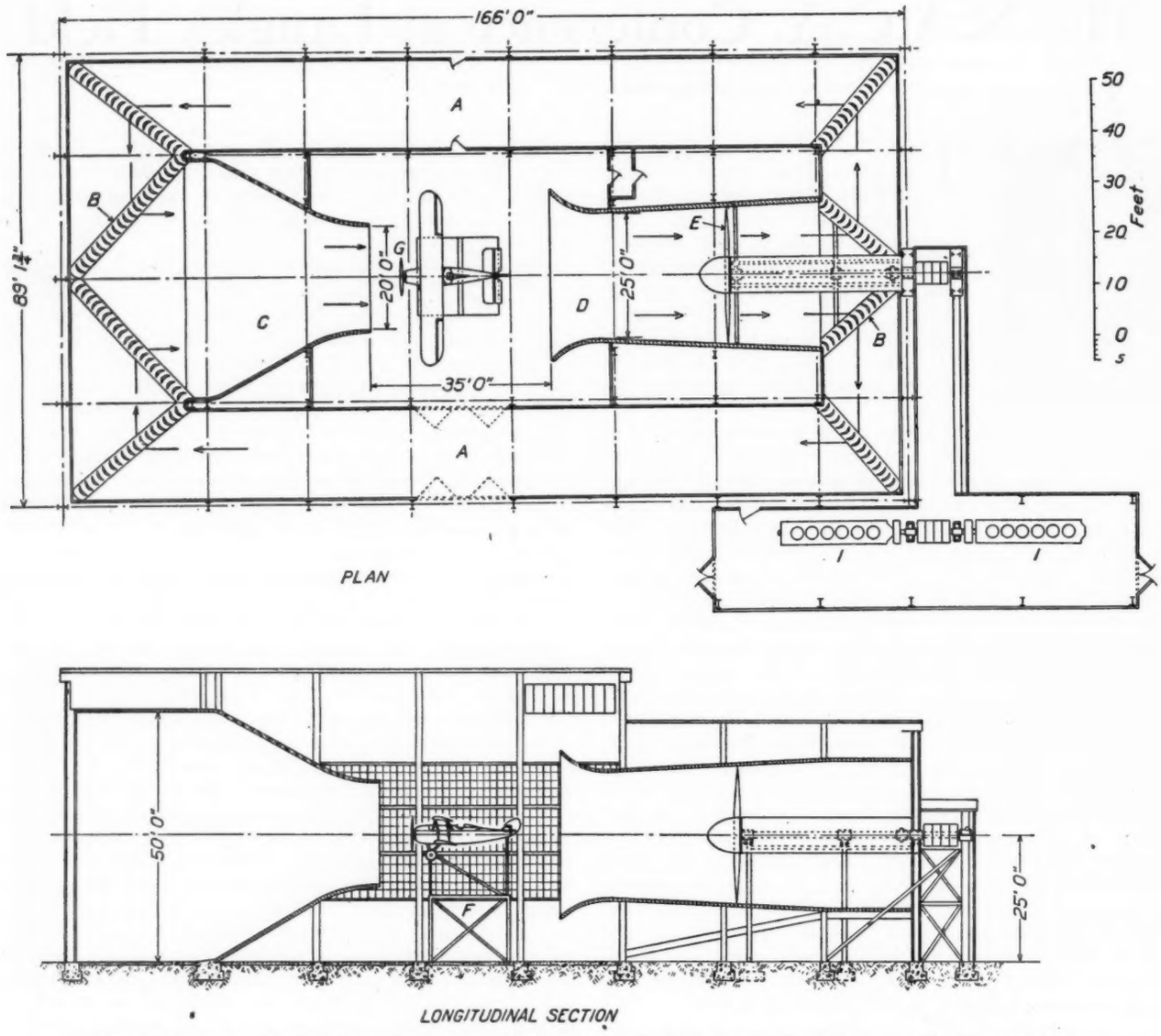


Fig. 1 Plan and Longitudinal Section of 20-Ft. Propeller-Research Wind Tunnel at Langley Field
(*A*, Return passage; *B*, Guide vanes; *C*, Entrance cone; *D*, Exit cone; *E*, Circulating fan; *F*, Balance; *G*, Test propeller; *I*, Diesel engines.)

that a steady condition can be attained for a run of at least 1000 ft., which with careful recording instruments is sufficient for the accurate determination of all the forces and moments involved.

Experimentation in Progress

It is impossible to review even briefly the immense amount of experimentation in progress. The Committee publishes many reports and technical notes which are read with great attention, not only in the United States but in every European country. We can only refer to those investigations to which attention was drawn by the various able young men of the Langley Field laboratories. The excellent plan is followed of allowing each of the young men engaged in research to present his own experiments to visitors with the aid of the experimental apparatus itself and of specially prepared charts and diagrams. Visitors are divided into three or four groups, carefully guided and shepherded. The entire process of visiting is entirely cordial, yet severely efficient.

Ice Formation

In the refrigerated tunnel, in which an insulated circulating tunnel is employed with heat extracted by coils of brine, a demonstration was made of Dr. William Geer's "airplane overshoes." The leading edge of the wing is fitted with a rubber covering impregnated with a special oil which freezes at low temperatures and reduces ice adhesion to a minimum. In case ice is formed, a tube lying inside the rubber covering is expanded by air pressure and the ice breaks away very readily. The demonstration of this process in the refrigerated tunnel was entirely satisfactory. Full-size experimentation has also been very promising, and it is hoped that the new device will overcome one of the last unsolved hazards of flying.

Aerodynamics Division

Elton W. Miller, reporting on behalf of the Aerodynamics Division of the Field, stated that the main subject of investigation at the laboratory now dealt with structural loading and investigation of drag and interference between parts of an airplane.

In the 20-ft. propeller-research tunnel, experiments were in process on the drag of various parts of a Fairchild cabin airplane. One interesting result of this research was that opening the win-

dows increased the drag 1.7 per cent. A preliminary analysis of the drag of this cabin monoplane gave the following results:

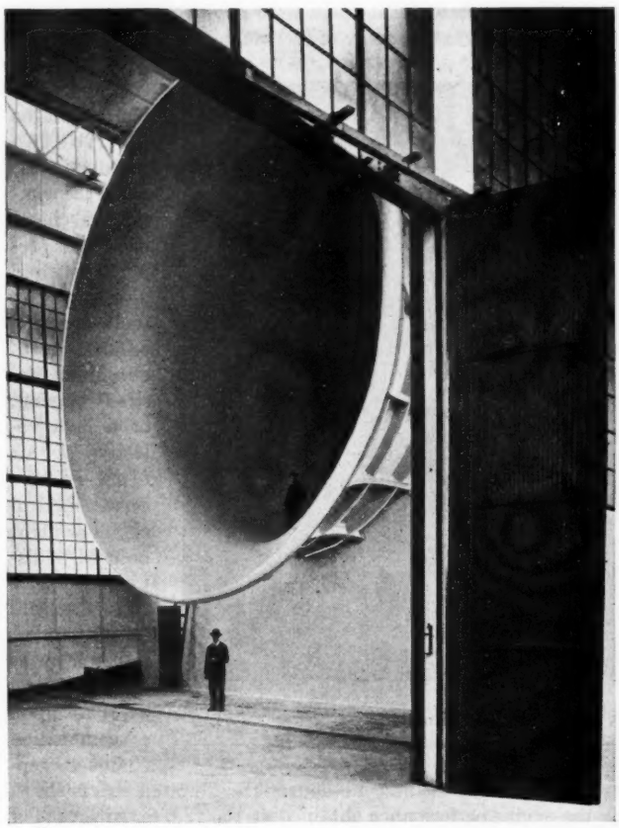


FIG. 2 EXIT CONE OF WIND TUNNEL SHOWN IN FIG. 1

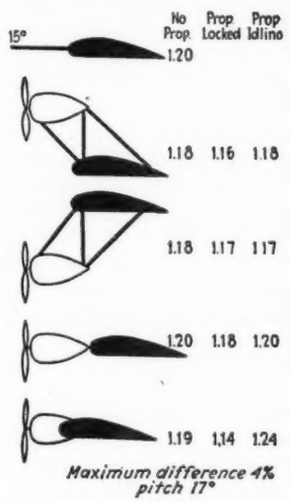


FIG. 4 RESULTS OBTAINED IN NACELLE-LOCATION INVESTIGATION

	Per cent
Wing and struts	49.6
Tail surfaces	4.7
Landing gear	13.4
Engine	16.9
Fuselage with turtle back	15.4

In the study of interference between parts, an investigation is now in progress with regard to the most advantageous position for a nacelle with reference to a wing as being of special interest to designers of multi-engined planes. The effect of a nacelle with a locked or idling propeller on the lift of the wing is also being carefully investigated. Fig. 4 gives a brief summary of the lift results obtained.

Other experiments dealing with interference included the effects of fillets between wing and fuselage of low-wing monoplanes, and the drag and interference of landing gears.

An interesting optical demonstration was given of what was possible in the way of decreasing resistance. A conventional airplane of 300 hp. had a speed of 139 m.p.h. With the N.A.C.A. cowling placed over the engine, speed was raised to 145 m.p.h. With landing gear retracted the speed increased to 165 m.p.h., and with a smooth nose to the fuselage, the speed was further boosted to 189 m.p.h.

AUTOROTATION AND FLOATING AILERONS

One of the most interesting exhibitions, made in the vertical 5-ft. tunnel, was that of the effect of the floating aileron on the autorotation of an airfoil. The floating aileron is a symmetrically double-cambered surface placed beyond the tip of each end of an airfoil, so mounted as to float freely in the wind and adjusting itself to zero incidence with the wind no matter what the angle of incidence of the airfoil as a whole may be. With the wing placed at a large angle of incidence and the floating aileron rigidly fixed, rapid autorotation of the usual character took place. With the tip ailerons free, autorotation ceased almost instantly. This indicated that the floating aileron may have important advantages in preventing spinning.

WORK OF THE FLIGHT RESEARCH SECTION

John W. Crowley, Jr., of the Flight Research Section, analyzed the factors involved in the problem of spinning as:

1 Aerodynamic forces and couples
2 Inertia.

One line of investigation consisted in dropping models in a spinning attitude from a considerable height; the results obtained by such drop tests were purely qualitative, but very interesting.

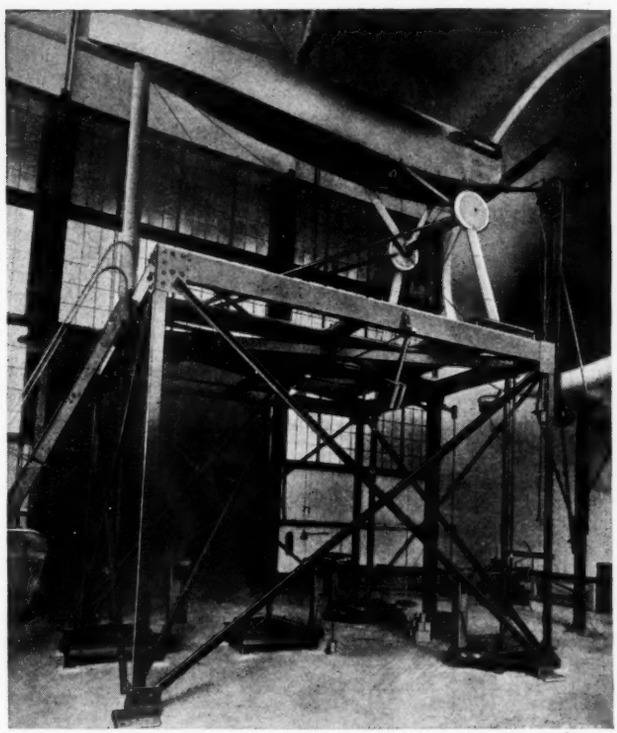


FIG. 3 BALANCE DESIGNED FOR USE IN TESTING FULL-SIZE AIRPLANE FUSELAGES IN 20-FT. WIND TUNNEL

Two types of suspension have been developed for determining the inertia of a complete airplane.

A N.Y.-1 airplane was being tested in flight to determine the effects of changes in weight, mass distribution, and balance on the spinning characteristics.

Table 1 indicates how changes in moments of inertia affect the radius of turn on this airplane in a spin.

FLIGHT OPERATIONS SECTION

The National Advisory Committee for Aeronautics is carrying out a rather extensive program of cowling research. An important line of research includes variable-angle cowling used to determine effects of changes in angle between cowling and thrust line. One cowling containing an integral exhaust manifold attracted much attention from the visitors.

PROPELLER RESEARCH

Results of investigations were presented by Fred E. Weick. As the outcome of tests in the Propeller Research Tunnel on full-sized fuselages, engines, and propellers, a number of useful charts have been compiled from which propellers can be easily and quickly selected to fit any ordinary tractor installation. A separate chart has been made of each of six different, typical, engine-body combinations.

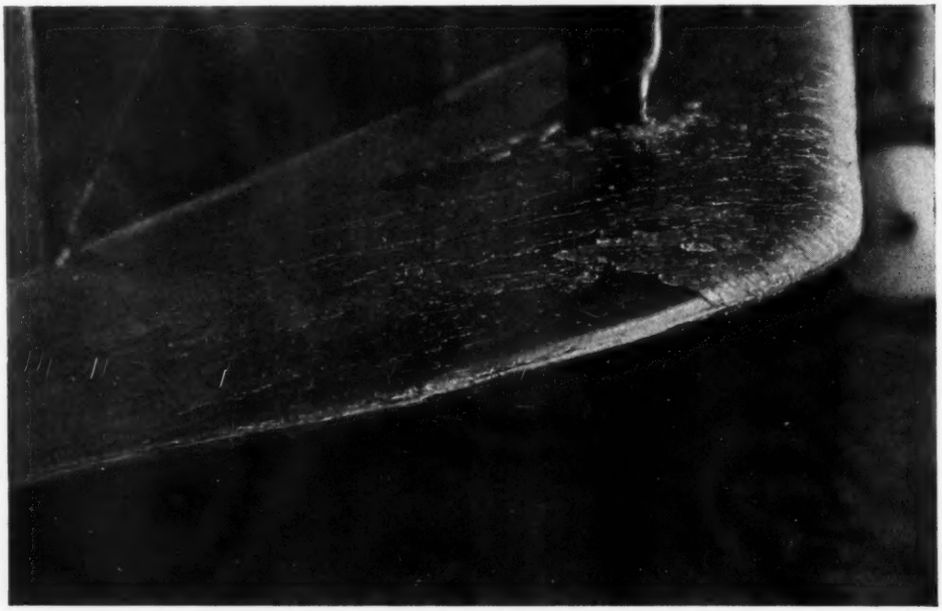


FIG. 5 FORMATION OF ICE ON AIRPLANE IN FLIGHT
(Light rain; temperature, —0.5 deg. cent.; average velocity, about 80 m.p.h.)

POWER PLANTS DIVISION

Carlton Kemper presented the results of work in this Division. Much work is being done by the Committee on the fundamentals of the aircraft Diesel engine; in particular, considerable progress has been made along the lines of predicting the injection characteristics of a given design of injection system. A method being developed permits the determination of instantaneous pressures obtained in the fuel-injection line during a single injection cycle.

Mr. Kemper stated that there were two general methods for obtaining an intimate mixture of fuel and air in the cylinder of an aircraft Diesel engine: The fuel might be distributed throughout the air in the combustion chamber by so proportioning and directing the fuel-injection orifices as to obtain the desired mixing; or a high velocity of air flow in the combustion chamber might be used to distribute the fuel. He said that at present research was being conducted upon a combustion chamber representative of each of these methods. He exhibited charts showing the engine performance obtained at 1550 r.p.m. with each of these combustion chambers.

Mr. Kemper stated that the Committee had conducted investigations to determine the characteristics of the Roots type supercharger, and that, in addition, comparative flight performance had been determined for a DH4 airplane equipped first with a Roots type supercharger and then with an exhaust-turbo supercharger. He said that the flight-test data were recorded by means of an automatic observer in the airplane. In addition to the determination of the speed and climb characteristics, Mr. Kemper stated that the specific fuel consumption was determined for the airplane when equipped with the exhaust-turbo supercharger. He then exhibited charts which showed the rate of climb and high-speed performance of the airplane equipped with the Roots and exhaust-turbo superchargers, and the specific fuel consumption of the airplane unsupercharged and equipped with the turbo supercharger.

TABLE I

Factors Affecting Spin

I. Aerodynamic forces and couples
  1 Rolling moment due to rolling
    A. Geometric proportions of airplane
      I. Airfoil sections, slots, etc.
      II. Washout, sweepback, etc.
      III. Biplane combinations
      IV, I, II, and III with controls deflected
  2 Rolling moment due to sideslip
    A. I., II., III., IV. } Same as above
  3 36 factors similar to above
II. Inertia forces and couples
  A. Inertia couples
  1 Moments of inertia
  2 Precessional moment due to prop.
  3 Wing loading
  4 Position of C. G.

N.Y.-1 Spins	Service	Altered
Weight	2390	2900 lb.
C. G.	25.7	41.2 per cent m.a.c.
I_x	2380	2376 sl-ft.^{2}
I_z	3887	4941 sl-ft.^{2}
Radius	4.5	9.3 ft.
1 Turn	2.5	3.5 sec.
Vert. vel.	79	95 ft. per sec.
Recovery	1	1 turn
Attack	49	48 deg.
Side slip	1	1 deg.
	2.4 sec. for complete turn	3.3 for same

DISCUSSION OF RESEARCH PROBLEMS

The afternoon session of the conference was devoted to the discussion of possible research problems to be undertaken by the Committee on behalf of the industry as a whole. These discussions of research have, in previous years, proved highly stimulating to the work of the Committee, and have been followed by some of the Committee's best investigations.

Dr. L. J. Briggs, of the Bureau of Standards, summarized the experiments conducted on airfoils at high speeds by the Bureau. Good conventional airfoils such as R.A.F. 6 and Clark Y, while excellent at speeds up to the speed of sound, lose lift and increase in drag at very high speeds. Improvement is being secured for high-speed work by moving the maximum ordinate of the airfoil further back from the leading edge. Very good results have

also been obtained with the section whose lower surface is plane, and whose upper surface is a section of a circular arc.

Capt. Robert W. A. Brewer, of the Aircraft Engine and Accessory Development Corporation, Jenkintown, Pa., suggested the investigation on the effects of a pusher propeller from the point of view of thrust and interference with the rest of the airplane. Captain Brewer also discussed the question of loss of lift which would occur with slots cut in a wing in designing wing radiators. He was also interested in the problem of propeller and exhaust noise.

Mr. Reid on behalf of the Committee stated that the Langley Field laboratories had started a program of investigation of this last problem. They were first of all looking into the method of measuring sound.

F. W. Caldwell, of the Standard Steel Propeller Corporation, Homestead, Pa., suggested the investigation of thin propeller sections for high-speed work. It is understood that the properties of propeller sections are being investigated in the high-speed tunnel where air issuing from an orifice under high pressure gives velocities comparable with the speed of sound.

R. Chilton, of the Wright Aeronautical Corporation, stated that the work his company was attempting to do was to determine definite limits to the advantages of supercharging an engine at ground level. A large degree of supercharging raised the temperature unduly. Mr. Chilton stated that there was a distinct need for studying detonation in relation to high compression ratio and high temperatures. Detonation, in his opinion, was tied up with the location, number, and temperature of hot spots. He thought it desirable to have a curve of the highest uniform compression ratio, with some particular standard range of fuel plotted against the air temperature measured at the inlet valve.

H. M. Crane thought that from information already obtained there was sufficient material to predict the form of such a curve, but the measurement of the temperature at the inlet valve was not easy.

Dr. H. C. Dickinson, of the Bureau of Standards, commented on the complexity of this problem owing to the large number of factors involved.

Charles Ward Hall, of the Hall-Aluminum Aircraft Corporation, Buffalo, N. Y., was interested in the question of the conventional cabin fuselage, with sharp angles at the nose. He suggested that the use of a small wing section mounted at the nose might smooth out the flow and prevent burbling.

Dr. Charles G. Abbot, of the Smithsonian Institution, inquired regarding the possibility of propelling an airplane by jet reaction.

E. N. Jacobs, of the Laboratory Staff, replied by saying that jet reaction was a very inefficient method of securing propulsion, unless a means was found to increase the thrust of the jet by increasing the momentum of the jet.

Dr. Karl Arnstein, of the Goodyear-Zeppelin Corporation, suggested that the value of the deceleration tests on airships at present being made by the Committee would gain appreciably by the incorporation of results from the tests of the new British airships.

Carl B. Fritsche, of the Detroit Aircraft Corporation, thought the results of the tests of recent German airships should also be made available.

A. E. Larsen, of the Pitcairn Aircraft, Inc., mentioned that their latest work on the autogyro included the development of a movable tail surface as a means of starting the autogyro blades and of a landing gear of large travel for almost vertical descent.

C. N. Monteith, of the Boeing Airplane Company, Seattle, Wash., regretted that there was no information for a logical method of correlating a vertical fin area with the dihedral of the wing.

B. V. Korvin-Kroukovsky, of the Edo Aircraft Co., and Prof. Alexander Klemin, of New York University, thought that semi-theoretical, semi-practical methods of calculation were already available.

W. H. Miller, of the Berliner-Joyce Aircraft Corporation, suggested that the work of the Flight Test Section of the Committee on pressure distribution during maneuvers should be supplemented by theoretical studies of these phenomena.

W. B. Stout, of Stout Engineering Laboratories, Inc., Dearborn, Mich., believed that the aviation industry had been stagnant from an engineering standpoint for two years, and advocated simplification of the present-day airplane. He predicted radical changes in the airplane of two years from now, in particular discussing the two-control airplane for the purpose of simplifying flying instruction.

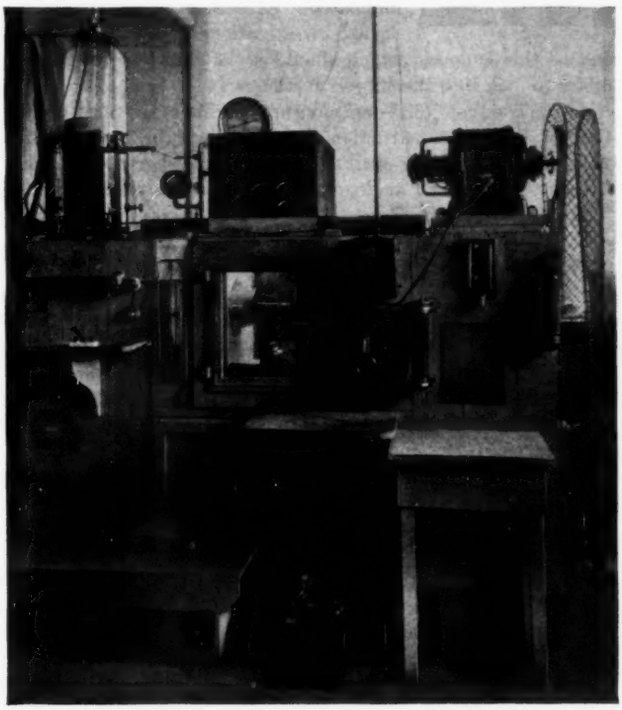


FIG. 6 GENERAL VIEW OF REFRIGERATED WIND TUNNEL AT LANGLEY FIELD

Grover Loening took the opposite view. He thought simplification was merely a slogan, and was of the opinion that, on the contrary, certain thoroughly sound engineering additions should be made to airplanes, such as silencers and variable-pitch propellers. He was much interested in the question of "how windows should be arranged on the fronts of cabins"—whether there should be one straight glass across the front of the cabin or whether it should be V-shaped. He thought there was a splendid field here for wind-tunnel work.

C. T. Porter, of the Keystone Aircraft Corporation, Bristol, Pa., pointed out the need for information as to the proper relation between propeller diameter and nacelle diameter to determine the proper gear relationship, and also stated he was very desirous of obtaining data on the cowling and cooling of tandem air-cooled engines.

W. B. Mayo, of the Ford Motor Company, Detroit, was interested in noise reduction, in investigation of nacelles in relation to wings, and in the study of tapered sections, and in the reduction of resistance where multiple engines in tandem are used on large airplanes.

Lubrication Research[1]

SOME of the major problems of lubrication research today are (1) Measurement and calculation of friction, (2) Effect of running in, (3) Effect of clearance and length, (4) Measurement and calculation of load capacity, (5) Pressure distribution in the film, (6) Temperature of the film, (7) Thin-film lubrication, and (8) Thick-film lubrication. These were briefly considered in the order indicated. References to previously published investigations will be found at the end of this synopsis which should be of value to readers who desire to look into the subject farther.

As the complete (360-deg.) journal bearing is the most familiar type of bearing construction, this type will be understood as the subject of discussion, except where otherwise specified. Other types present analogous problems for investigation.

Measurement and Calculation of Friction

The experimental measurement of the friction of bearings is the foundation of research on lubrication. The methods proposed for measuring frictional resistance are exceedingly numerous and have apparently never been fully catalogued or even classified. They include measurement of electrical power absorbed, measurement of heat developed, and deceleration observations as well as direct mechanical torque measurements (References 1–10, for example).

A curious fact pointed out by Harrison (11)[2] is that the frictional torque on the journal is not in general equal to the torque on the bearing, on account of the eccentricity of the journal. In order to compute the power lost in friction it is necessary to know the torque acting on the journal, whereas most experimenters in the past have measured the torque on the bearing.

Theories of lubrication can be tested by comparing the calculated and observed coefficients of friction. Ordinarily the coefficient is plotted against speed, load, viscosity, or other variables, taken one at a time, each therefore requiring a separate chart. Dimensional analysis (12, 13) justifies the simpler procedure of choosing for abscissa the combination variable, speed multiplied by viscosity and divided by load. This results in concentrating a large number of plotted points on a small number of curves, thus enhancing the accuracy of the curves and facilitating the construction of empirical equations.

The most obvious purpose of any theory of lubrication is to aid the designer in predetermining the friction loss of a proposed bearing under the various operating conditions. Petroff's formula (14, 15) was the first, and still remains practically useful as an approximation applicable only to lightly loaded, high-speed bearings where the film can be assumed to be of a uniform thickness throughout. Under these conditions the frictional resistance is independent of the load, directly proportional to the surface speed and to the viscosity of the lubricant, and inversely as the clearance.

Reynolds (16) attacked the more complicated case of an eccentric bearing, where the film is not of a uniform thickness. The result of his study is known as the hydrodynamic theory of lubrication. Although his own application was limited to partial bearings, the theory has been further extended by numerous later investigators (17). Sommerfeld's prediction of a minimum point (18) in the coefficient-of-friction curve is one of the most interesting deductions from the hydrodynamic theory.

Effect of Running In

Just what happens to the coefficient of friction curve when a bearing is gradually run in was shown quantitatively by S. A. McKee in a paper before the A.S.M.E. at the 1927 Annual Meeting (19). The friction loss of a well-run-in bearing under certain operating conditions may be as little as half that of the same bearing when new. At the same time the minimum point is progressively shifted toward lower speeds and heavier loads. This increases the factor of safety of the bearing with respect to overloading and overheating, since the minimum point marks a transition from unstable to stable lubrication. These experiments will be extended when possible to bearings of larger size.

Effect of Clearance and Length

Twenty-one different sets of bearings (four in a set) were investigated by S. A. McKee and T. R. McKee to map out graphically the effect of variations in clearance-diameter ratio and length-diameter ratio on the coefficient of friction. For bearings as short as one-quarter of the diameter, the measured coefficients were found to be as much as 0.013 greater than those computed from theoretical formulas that neglect end leakage. This investigation was one of several at the Bureau of Standards which are financially supported by the Special Research Committee on Lubrication of the A.S.M.E. The results were presented at the 1928 Annual Meeting (20).

Measurement and Calculation of Load Capacity

The greater the permissible bearing pressure or load per unit of projected area, the shorter the bearings of a machine can be. This reduces the total friction loss as well as economizing on space and weight. Various criteria for safe load have been considered at different times and experimentally investigated with varying degrees of success, including (*a*) seizure, (*b*) excessive heating, (*c*) film rupture, (*d*) film thickness, (*e*) the minimum point (1, 2, 6, 17, and 21–23, for example).

While much can be said in favor of the minimum-point criterion, present-day machine design is in fact more commonly based on the selection of an arbitrary limiting value for the film thickness at point of nearest approach (24). It is accordingly interesting to note the conclusion to be drawn from dimensional analysis, viz., that the load capacity corresponding to a fixed film thickness is directly proportional to the product of the speed by the viscosity (13, 15).

Pressure Distribution in the Film

The lubricant adheres to both the moving and the stationary surface and by virtue of its viscosity develops a positive fluid

[1] Synopsis of an address by Mayo D. Hersey before the Detroit Section of the A.S.M.E., February 17, 1930. Mr. Hersey is Chief of the Friction and Lubrication Section, Bureau of Standards, and a member and former chairman of the A.S.M.E. Special Research Committee on Lubrication. He is a graduate of Massachusetts Institute of Technology in mechanical engineering. He received his A.B. and A.M. degrees in physics at Colorado College and at Olivet College, respectively, and was a graduate student of physics at Harvard University (Whiting Fellowship) 1915–16. For two years he filled the position of associate professor of properties of matter at M.I.T., after which he was stationed at Pittsburgh, Pa., as physicist in charge of the physical laboratory of the United States Bureau of Mines.

[2] Numbers in parentheses are those of references given at the end of the text.

pressure in the converging portions of the film. This pressure supports the load and prevents metallic contact, as was first explained by Reynolds. The load-carrying capacity of a bearing can therefore be computed from a knowledge of the pressure distribution. Reynolds also showed how the frictional resistance can be computed from the pressure distribution. Several experimental investigations of pressure distribution applicable to journal bearings and thrust bearings are in progress at this time, from which exceedingly interesting results may be expected within another year.

TEMPERATURE OF THE FILM

No part of the field of lubrication research appears to have been so systematically neglected as the determination of the true temperature of the film, including the distribution of this temperature when non-uniform, and the temperature-time curve before equilibrium has been reached. Some parts of the problem have been found amenable to dimensional analysis. The use of electrical heating coils in place of the oil film has been advocated as a step in determining the heat-transfer characteristics of different bearing constructions experimentally (13, 15), and the necessary equations for a thermodynamic solution have been pointed out (6, 15). Boswall offers an approximate method for calculating temperature rise (25), while Michell has discussed the question of thermal instability in the oil film (26). Empirical data on thermal constants of oil-ring bearings have been given by Karelitz (24).

THIN-FILM LUBRICATION

In the lubrication of gear teeth, screw threads, cutting tools, and many other bearing surfaces operating under high-pressure, low-speed conditions, it is generally impossible to maintain a thick fluid film. Under such conditions certain lubricants, notably lard oil, give less friction than others of equal viscosity (17, 27–31). Some additional property of the lubricant besides viscosity is evidently involved. This property is called "oiliness," and constitutes the center of interest at present in lubrication research. It cannot safely be assumed, however, without experimental proof that oils which are high in oiliness will necessarily be better than other lubricants for reducing wear, or for preventing seizure.

Various methods for measuring oiliness have been proposed and will be intercompared in the near future. To support this work, as well as the journal-bearing experiments previously mentioned, funds are being collected by the A.S.M.E. Special Research Committee on Lubrication (32).

The effect of high pressure, which is known to greatly increase the viscosity of lubricants, may be a contributing factor in the explanation of oiliness, wear, and seizure. High spots on the rubbing surfaces, approaching tangentially, must create intense local pressures momentarily. This problem has been studied by the Special Research Committee on Lubrication as well as by investigators in England and Germany (33–38). A coordinated summary of results is in preparation. Many oils solidify or become plastic at pressures of the order of 25,000 lb. per sq. in. These effects can readily be demonstrated by pumping a heavy oil or soft grease through a long metal capillary into the free atmosphere. Paradoxically, raising the inlet pressure beyond a certain point diminishes the rate of flow.

The relation of oiliness and other factors to cutting-tool lubrication was indicated in a report prepared for the 1928 Annual Meeting at the request of W. W. Nichols, Chairman of the A.S.M.E. Special Research Committee on Cutting of Metals (39, 40).

THICK-FILM LUBRICATION

A working model of the Kingsbury thrust bearing, lubricated by means of an air film, was shown in order to illustrate the necessary conditions for thick-film lubrication (31). While continuous effort must be devoted by research laboratories to the solution of thin-film-lubrication problems, notably oiliness, wear, and seizure, practical engineering design should be directed toward the maintenance of thick-film lubrication. Under these conditions the performance of a bearing is independent of the composition of the bearing metals, and does not depend upon any property of the lubricant except the viscosity. The secret of thick-film lubrication, with consequent freedom from wear except at the moment of starting or stopping, and with greatly reduced friction losses, lies in the principle of the converging film discovered by Osborne Reynolds.

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An Unemployment Remedy—An English View

THERE is a movement on the Continent in favor of bringing down selling prices by a reduction of wages, in the hope that a larger consumption of goods will provide work for the unemployed. Wage earners cannot ignore the fact that the higher prices of most goods and commodities have followed, and not preceded, advances in wages, and as a large proportion of consumers have not had their wages and salaries increased to a similar extent there is naturally a reduction of purchasing power. If, therefore, goods can be sold at prices that will bring them within reach of the classes, usually professional, which are obliged to economize because their salaries remain with little change, while the wages of workmen have largely increased, there will be some hope of returning to normal conditions of supply and demand. An experiment of this kind is to be tried in Germany. The situation there is so bad, with an unemployment figure that exceeds the total in this country, that any remedy which offers promise of doing something is better than nothing at all.

As the proposal to reduce wages is based on apparently sound economic principles, the men's unions have decided to give it a trial in those industries in which a lowering of selling prices may be expected to stimulate a demand and therefore provide more employment. The details of the experiment are now being worked out by employers and the men's unions, and it is believed that they will have no difficulty in settling upon a rate of wages reduction in proportion to the diminution of selling prices. The experiment, if successful, will have important consequences in directing attention to what appears to be a rational means of increasing consumption, and thereby helping to solve the problem of unemployment.

A few years ago the Henry Ford principle that high wages resulted in high purchasing power, and consequent large trade, was very widely accepted. Mr. Ford himself put it forward in a convincing manner in his "Today and Tomorrow." He pictures, as it were, an ever-accelerating wheel—more wages, more work; more work, more wages; and so on and on to the *n*th power. There seemed to be no limit to the possibilities. He looked upon his employees as his best clients, and there was no reason why he should not increase the number of both at once. It was a rosy picture which caught the fancy and fired the imagination of many until it became a sort of tenet in certain circles that nothing more was needed to insure employment, and the possession of all that the heart could desire, than an ever-increasing rate of wages. But in economics things have a disturbing habit of refusing to follow doctrinaire anticipations, particularly when sufficient care is not taken to lay down strictly the conditions.

People who saw the Ford scheme in operation in Detroit thought that it could be transplanted at once in any part of Europe, including this little country, which lives only by its ability to compete in open markets with much bigger and more self-sufficing lands, lands to which foreign trade is not all in all. We do not know if the plan is going just as well as Mr. Ford expected, even in Detroit, but it is obvious from the estimates of unemployment that it is not working out "according to plan" in the United States as a whole, and in Europe it has never even glanced at success. Mr. Ford could follow the principle because he had a great new industry in a great country with incredible possibilities of development; but in the Old World it could not be done. Wages rose indeed, but only because the price of commodities had risen, and the price of commodities could not be induced to fall while the price of the labor which produced and handled them went up. Now we see an effort to improve matters by moving in the opposite direction.

The thought must have occurred to every one who thinks at all, that if the price of a single necessity of decent existence could be brought down, then, in a well-ordered world, the price of everything else would fall in sympathy, because since the purchaser of the first commodity would have to spend less upon it he could do with less wages—for the same measure of comfort—and so the cost of the article that he produced would also diminish. That scheme is in operation on the railways of Great Britain, the rate of wages of the men in certain grades varying up or down according to the cost-of-living index. It has had very little general effect; possibly because the cost of rail transport has not a sufficiently direct influence upon the cost of goods. The lowering of freight rates cannot be immediately reflected in the price of commodities, in the total cost of which they form only a small item. It seems, therefore, that we can never see the economics of the problems follow the course that it would follow were it a proper scientifically behaving thing, not a thing that "gangs its ain gait" in defiance of the professors. The snowball effect for the multiplication of the value of the sovereign is past praying for. A better result may follow from an attempt made in the gross, and it appears that the Continent, particularly Germany, is going to make the experiment. If it be true that the trades unions of that country have really agreed to a reduction of wage rates with the object of encouraging trade and reducing unemployment, we may see some interesting results.—*The Engineer*, vol. 149, no. 3883, June 13, 1930, p. 661.

Casting in Permanent-Mold Machines

Description of a Process of Producing Castings in Great Quantities

THE ordinary foundry is notorious for the amount of time and labor consumed in performing comparatively simple operations. Various investigators claim that for one ton of metal cast, from 12 to 28 and more tons of material have to be handled. Lately a consistent effort has been made to improve this condition, particularly where a large number of castings of the same kind have to be produced and where the castings are not complicated. Permanent-mold casting is an instance of one solution to this problem.

It should be clearly understood that permanent-mold casting is not applicable in every case, as the machinery in which they are made is somewhat expensive. The installation of such a method of casting is therefore justified only where the number of castings to be produced is so large that the initial cost becomes small in relation to the total. Permanent-mold casting is therefore only applicable in mass production and is obviously entirely unsuited to jobbing work. However, it seems to be economical and effective when employed under proper conditions.

The permanent-mold process described in the present article is that employed by the Holley machine which uses ordinary cast-iron molds. In the Holley machine it has been possible to eliminate the rapid wear of the surface of the molds. In the past it has been found that where cast-iron molds were used their surfaces were quite rapidly destroyed and became rough. A number of reasons for this may be found. In the first place, there is a certain amount of oxidation due to the interaction of the air and the hot exposed surface of the mold after the removal of the casting. Whether this oxidation attacks the carbon or the iron is still not quite clear, but the result is a roughening of the surface and ultimately the production of cracks. To some extent this can be obviated by rubbing, but this would entail a considerable amount of manual labor, and in the case of small somewhat complicated molds would not be practicable. Numerous attempts have been made to prevent this undesirable action by coatings, tarring, smoking, etc. The manufacturers of the Holley machine have succeeded in producing an effective coating. This coating, which is said to be patented, is a solution in one gallon of lukewarm water of 6 oz. of C-grade sodium silicate and 12 oz. of English pipe clay. The resulting wash is applied until the coating is a little under $^1/_{64}$ in.

This coating has the appearance of whitewash and is applied, by painting, to the molds that have been previously heated to about 400 deg. fahr. It dries rapidly leaving a refractory skin that does not peel or rub off. It is said that it is only necessary to apply this coating once a day.

The principle of the operation of the permanent-mold machine is illustrated in Fig. 1, which shows a machine of the turntable type. Each mold is divided along a vertical plane into two parts that are opened and closed automatically. Previous to each casting the molds are cleaned by a blast of compressed air and are then coated with lampblack. This lampblack is produced by burning acetylene gas in a specially designed burner which deposits an even layer of lampblack all over the surface of the mold. Next the core is set, if one is required, and then a further movement of the turntable closes the mold. The mold is then brought opposite the ladle from which it is filled. As the turntable travels further the casting sets, the mold opens, and the casting drops out. The time intervals are arranged so that the castings are ejected as soon as possible.

It is clear therefore that in one revolution of the turntable as many castings are made as there are stations or molds, although machines having only a single mold are built for experimental purposes or for making special castings. Moreover while each mold usually makes a single casting, in the case of very small castings molds have been made to cast several at once. The time required for a complete revolution of the turntable depends on the size of the casting and is from $1^1/_2$ to 4 min. The backs of the molds have cooling pins taking the place of the usual cooling fins, and subjected to a blast of air. The castings are annealed at 1600 deg. fahr., then snagged, and cleaned either by tumbling or by sandblasting. The standard analysis for castings is as follows: Total carbon, 3.50; silicon, 2.50; sulphur, 0.08; phosphorus, 0.30; and manganese, 0.55. The anneal is of course necessary in this case as otherwise there would be a certain tendency toward

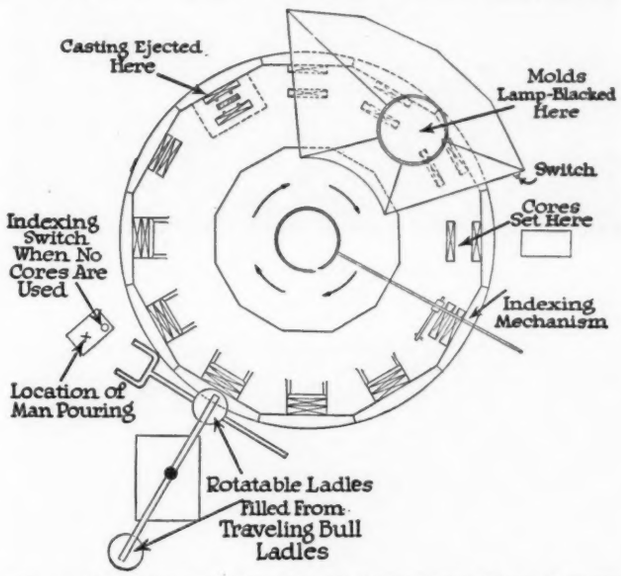

FIG. 1 DIAGRAMMATIC OUTLINE OF PERMANENT-MOLD CASTING MACHINE

chill at the outer surface with consequent undesirable results. It appears that the anneal increases the resistance to impact as well as the resistance of iron to growth, which, from general experiences with such materials, would be expected.

Tests have also indicated a striking increase of permeability of machine-cast iron as compared with the usual sand-cast material. This is important as there is apparently a distinct connection between permeability and lack of porosity.

Fig. 2 is a photomicrograph of the metal as cast in a Holley machine, showing graphitic carbon which would indicate that the photograph was taken from the inside of the casting rather than the outermost layer.

Fig. 3 shows the iron annealed at 1500. Fig. 4 shows it at 1550, and Fig. 5 at 1600 deg. fahr., the latter being the standard practice. Each anneal lasted for one-half hour.

Permanent-mold castings show a considerable saving in machining due in part to the uniformity of the grain structure produced by the anneal and in part to the absence of the usual sand skin which is particularly hard on tools.

The more recent machines for large production are of the turntable type shown in Fig. 1, carrying twelve molds which are opened and closed automatically. One design employs compressed air to open and close the molds while the other is mechanically operated throughout. The machinery requires two operators on solid castings and three when cored castings are being cast.

Of late two interesting developments in this method of casting have been made. The first is the casting of radiators for domestic heating purposes for which an exclusive license has been issued. The other is the casting of cast-iron soil pipe. These two applications indicate the wide range of products that can be cast in permanent molds of this kind.

When it comes to economic considerations, it is obvious that the advantage of the permanent-mold machine lies in the elimination of considerable amounts of handling and labor. If the same castings were made in sand, a certain amount of sand of proper consistency would have to be prepared for each casting. Next would follow the molding operation which necessarily requires care and some skill. This is followed by the casting proper, whereupon the castings must be shaken out of the sand and the sand must be returned to the molding floor. Each of these operations involves an expenditure of labor and power as well as the use of considerable amounts of floor space. In the permanent-mold machine three men paid the wages of unskilled laborers and standing by a turntable perform all the necessary operations in a somewhat leisurely manner. As the turntable delivers, say, 12 castings in each period of from $1^1/_2$ to 4 min., it is obvious that there is a saving in labor. It is also very likely from observation of the operation that the amount of wasted castings must be quite small.

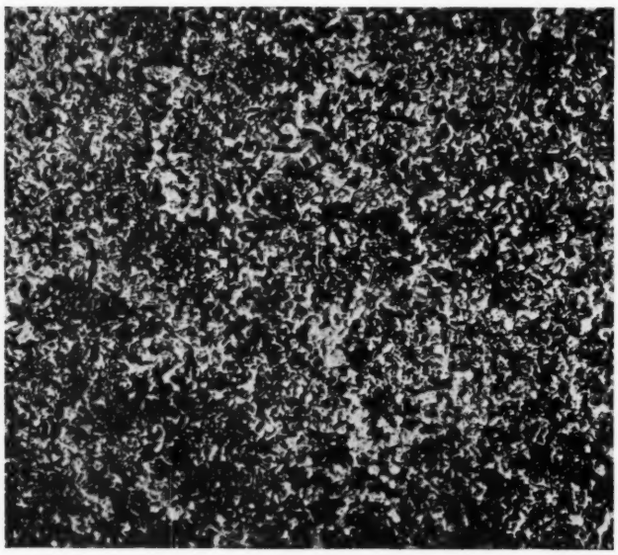

FIG. 2 STRUCTURE OF METAL AS CAST IN HOLLEY PERMANENT-MOLD MACHINE
(Magnification × 100.)

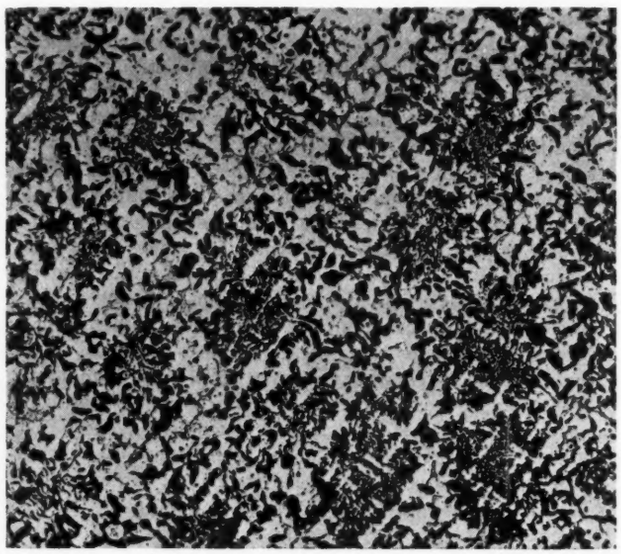

FIG. 3 STRUCTURE AFTER ANNEALING FOR ONE-HALF HOUR AT 1500 DEG. FAHR.
(Magnification × 100.)

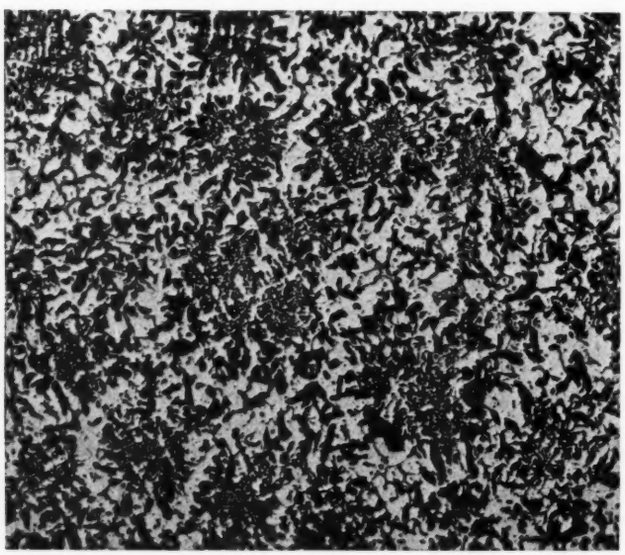

FIG. 4 STRUCTURE AFTER ANNEALING FOR ONE-HALF HOUR AT 1550 DEG. FAHR.
(Magnification × 100.)

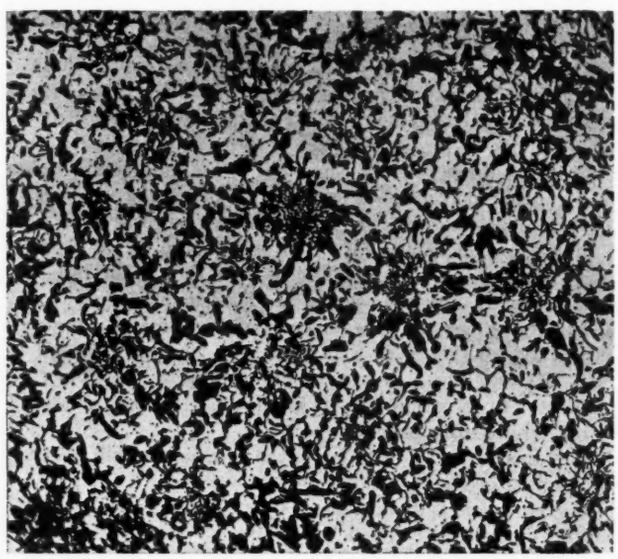

FIG. 5 STRUCTURE AFTER ANNEALING FOR ONE-HALF HOUR AT 1600 DEG. FAHR.
(Magnification × 100.)

Tungsten-Carbide Cutting Materials

Progress Report No. 2[1] of Subcommittee on Tungsten-Carbide Cutting Materials of the A.S.M.E. Special Research Committee on the Cutting of Metals

By FRANK C. SPENCER,[2] KEARNY, N. J.

WITH THE assistance of the National Machine Tool Builders' Association, this subcommittee has sent out letters and questionnaires to over six hundred users and builders of machine tools requesting certain specific information based on their experiences with the use of tungsten carbide as a cutting material. It was thought that the analysis of a large amount of data obtained in this manner would bring to light such deficiencies as might exist in the tools and in the machines which, if corrected, would make it possible to obtain the maximum advantage from the use of this material. Copies of the letter and questionnaire are included as a part of this report.

About seventy-five concerns had replied at the time this report was prepared, of which about fifty furnished data on most of the items covered by the questionnaire. The others were making tests but had no information available, or had not used tungsten carbide at all. Replies are being received daily, and it is hoped that sufficient information will be obtained to warrant the preparation of a more complete report later. The following is a digest of about fifty replies presenting experiences with the use of tungsten-carbide tools and comments of users bearing upon the design of machine tools.

A—Extent of Application

The returns show that a relatively small average number of machining operations are now being regularly performed using tungsten-carbide tools, although in two companies the number of applications is over 500 in each. Probably a better indication of the extent of application is the low percentage of the number of tungsten-carbide tools to the total number of tools available. This percentage is considerably less than one per cent; but there are, however, several notable exceptions—one machine-tool builder reports 5 per cent, one 15 per cent, and another 25 per cent. One company is using tungsten-carbide tools for 75 per cent of all cast-iron turning.

While the total volume of production now being obtained with the use of tungsten-carbide tools is still relatively small, the replies indicate that practically all of the companies reporting have definite programs planned which contemplate the more extensive use of tungsten carbide, provided that "tests which are now being conducted prove to be satisfactory."

One company is planning to equip 1000 machines with tungsten-carbide tools for the general machining of metals, and another is conducting a test which, if it "shows that a saving can be effected, plans to use them exclusively on all cast-iron, semi-steel, bronze, and brass machining," with the possibility of extending the application for machining 1000 different parts.

B—Kind of Material Cut

Experiences indicate that tungsten carbide is superior to tool or high-speed steel as a cutting material on all non-ferrous metals regardless of the hardness or the condition of the surface, especially for roughing cuts on production jobs. Not all are agreed, however, that finishing can be done as satisfactorily as with high-carbon- or high-speed-steel tools, because "tungsten carbide is comparatively weak and brittle," and "will not hold a fine, keen edge."

Cast iron submits readily to the tungsten-carbide tools even when the surface has a hard sandy scale. One company reports, "We have to cut through chaplets and welds where blow-holes have been acetylene welded. Tungsten carbide does not seem to fail in cutting through these defects." Others report similar experiences.

A difference of opinion exists as to the advantage of using tungsten-carbide tools in machining steel. Several report failures in attempts to improve on high-speed-steel performance, while others are enthusiastic about the use of tungsten carbide for machining steel and report having readily machined alloy steels which could not be machined economically with high-speed steel. One company reports machining a hand-forged nickel-chromium steel airplane propeller shaft. It is stated: "It was extremely tough and irregular in shape, necessitating in frequent instances materially heavier cuts on one side than on the other. Scale conditions and hard spots were particularly difficult." The shaft was turned on a Gisholt turret lathe about 10 years old but in good condition. "The job was successfully completed using tungsten-carbide tools—as we found it absolutely impossible to finish the machining of the parts using high-speed-steel tools without first annealing the forgings, and then only with great difficulty."

C—Machine Equipment Used

Machines on which tungsten-carbide tools have been used successfully on regular production include practically all standard types of metal-cutting machines, except milling and drilling machines which, replies indicate, have been equipped with tungsten-carbide tools for use principally on an experimental basis.

The machines on which tests were made or on which regular operations were being performed in most cases were reported in good condition. Two reported as follows: "Condition varies from good to poor, much more satisfactory results being obtained from machines in good condition." An electric company, in

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[1] This report was presented at the Machine Shop Practice Session of the A.S.M.E. Semi-Annual Meeting in Detroit, Mich., June 9, 1930.

[2] Assistant Superintendent, Manufacturing Development, Western Electric Co. Mem. A.S.M.E. Mr. Spencer was employed as a draftsman in the Ordnance Department at Washington during 1902 and 1903, and in 1904 was appointed chief draftsman at the Springfield Armory, Springfield, Mass. In 1918 he held the position of superintendent of the Browning Gun Department at the Colt's Patent Fire Arms Manufacturing Company at Hartford, Conn., but during most of the time since 1906 he has been employed by the Western Electric Company in various capacities, starting as machine designer at the Chicago plant. In 1923 he was placed in charge of the machine-design division at Hawthorne and in 1925 was appointed assistant superintendent in charge of manufacturing development. During the last couple of years he has been engaged principally in the procurement of machine equipment for the new plants of the Western Electric Company.

referring to its equipment, stated, "Generally one will find the equipment in fair condition and about 5 to 10 years old. Tungsten carbide can be used advantageously on machines of this age provided the proper selection of the tool is made."

D—Tungsten-Carbide Tools Used

Practically all of the tools used by the companies reporting were lathe- or planer-type tools in a large variety of shapes and sizes, some having shanks as large as 2 in. × 2½ in. Tips in most cases were simply brazed, though a few were inserted, and in one or two cases they were dovetailed and brazed. The rake and clearance angles in most cases were those recommended by the suppliers, but in some instances customers found modifications of these angles desirable on certain kinds of work. This subject is sufficiently important to warrant further consideration, and it will probably constitute one of the Commitee's future activities.

E—Grinding of Tungsten-Carbide Tools

As reported above, lathe and planer tools constituted a large majority of the tungsten-carbide tools reported upon, and the grinding was done mostly by hand. Eight out of thirty companies reported using cutter-grinder machines also. A few of the companies have the grinding done by the suppliers One company reports grinding "not essentially different from standard tool-dressing methods;" another, "Tools were ground in our tool room by one man, who was instructed as to proper methods."

A gear company cutting cast iron, brass, and bronze castings reported that the time consumed in grinding is from one to three hours, according to the condition of the tool. Another stated that the time required is twice that for grinding high-speed-steel tools, while another, machining bronze, reports three to five minutes as the average time required.

A company machining "nearly all commonly used materials" reported that "considerable time was spent in sharpening tools, and we found it difficult to maintain a keen edge for any length of time." Another shop doing very heavy work stated that "after original grinding, only a few minutes each day is required for occasionally touching up the cutting edge." A company machining aluminum alloys reports the time for grinding is negligible, and another reports the time consumed about 5 times that of high-speed-steel grinding.

Apparently the practice of grinding tungsten-carbide tools differs as greatly as the grinding of tool-steel and high-speed-steel tools. The importance of maintaining the correct rake and clearance angles on tools used for production work which can only be accomplished by machine grinding, seems to be generally disregarded. The subject of small-tool grinding warrants further investigation.

F—Method of Lapping

Of 40 companies, 11 reported the use of tungsten-carbide tools lapped or stoned. The lapping has been done mostly by hand, using a cast-iron lap, though in a few cases disk lapping machines are used, silicon carbide or diamond dust with oil being used as an abrasive. The advantage of lapping tungsten-carbide tools is questionable.

G—Cutting Speeds Used in Feet per Minute as Compared With Cutting Speeds of Tools Previously Used

The increases in cutting speeds using tungsten-carbide tools in cutting cast iron and non-ferrous metals have been from two to three times the cutting speeds using high-speed-steel tools. Many are using the highest speed that the machines will permit. One report stated relative to cutting bronze, "We have made several tests of cutting speeds and have got as high as 400 ft. per min., but could not maintain this due to the construction of our machine tools." Another reported: "In a few cases where we originally tried to get full speed and feed capacity of the tool, the strain on and chatter of the machines was so great that we had to cut the speed down, and we are now only increasing speeds gradually as operators get familiar with the tool possibilities."

H—Feeds Used in Inches per Revolution or Stroke as Compared With Feeds on Tools Previously Used. I—Depth of Cut in Inches

The general practice seems to be to use about the same feeds and depth of cut in cutting with tungsten-carbide tools as with high-speed-steel tools. No radical differences have been reported. A tendency is indicated, however, toward lighter feeds, with much higher cutting speeds than are used with steel tools.

J—Economies in Percentage of Increased Output as Compared With High-Speed Steel and Stellite

Some remarkable increases in outputs per grind using tungsten-carbide tools for machining cast iron and non-ferrous metals have been reported, as compared with high-speed-steel tools. These increases appear even more remarkable when we consider that the cutting speeds used as already noted were in most cases from two to three times former speeds using high-speed-steel tools.

A company machining silicon-aluminum alloys reports that with the use of tungsten-carbide tools they obtained 4500 to 35,000 pieces per grind, whereas with the use of high-speed-steel tools they obtained 100 to 1800 pieces per grind. An airplane company in turning aluminum bronze obtained 2000 pieces per grind using tungsten carbide, against 60 pieces per grind using high-speed steel, and in boring aluminum-alloy crankcases having 8 bearings each, 50 to 75 crankcases per grind using tungsten carbide, against one using high-speed steel. Another airplane company stated that they could not report on the output of some of their tungsten-carbide tools because of the fact that the set-ups have not been disturbed since the tools were first put to work more than six months ago.

A company machining cast iron reported 1500 pieces per grind using tungsten carbide as against 100 using high-speed steel. They also reported that in grinding they do not remove more than 0.003 in. to 0.005 in. from the tungsten-carbide tool, whereas up to 1/32 in. is ground away each time the high-speed-steel tool or stellite tool is ground. Another company machining cast iron reports the number of pieces per grind using tungsten carbide is 1500 per cent over the number using high-speed steel, and the increase in the number of grinds in the life of the tool "due to the small amount removed in grinding would be about 200 per cent."

A valve company machining non-ferrous metals reported as follows: "As compared with high-speed steel, one particular job shows an increase of approximately 2400 per cent in pieces per grind and an increase of approximately 560 per cent in the number of grinds per tool. On another operation where tungsten-carbide tools replaced high-speed steel, the number of pieces per grind increased something like 1600 per cent."

Practically no information was furnished relative to a comparison of tungsten-carbide tools with stellite tools with respect to the output per grind.

Longer runs without the necessity of shutting down for tool grinding result in an appreciable increase in machining production efficiency, without the necessity for spectacular increases in cutting speeds. Large economies are effected with the use of tungsten carbide on such operations, even when used on equipment that was not designed for the severe service tungsten carbide will withstand.

Considering the gain in production resulting from long, uninterrupted runs combined with the gain resulting from the high

cutting speeds obtainable with this material, the possibilities of cost reduction are considerable.

K—Failures

A few companies reported no failures whatever, although most of the companies including those which have been able to effect satisfactory savings using tungsten-carbide tools have had several discouraging experiences—some due to unsatisfactory tools, some to machine deficiencies, and some no doubt to unfamiliarity with the technique involved in the use of the material.

With respect to tool troubles, one large company stated: "We have had set-ups which gave us considerable trouble, and which finally worked out only after a new set of tools was installed by changing suppliers. We believe that tungsten carbide is very inconsistent in hardness and grain structure, and that the tipping is not always satisfactory, which generally causes failure of a set-up." Another stated: "Our failures have been under heavy cuts which caused the shank of the tool directly under the cutting edge of the tungsten-carbide bit to compress and mushroom out, causing the tip to break due to improper support."

One large company's report summed up the statements of several: "Have had the usual failures experienced by others, such as those due to tools having too great overhang, to making intermittent cuts, to operator stopping machines and starting again with feed on, to operator running machine in reverse accidentally, to not exercising care when tool leaves the work, and when blowholes are encountered."

Quoting from reports of other companies: (1) "We could only increase speed a little before we reached the maximum speed of machine, and when we attempted to increase the feed, the tips came off." (2) "The only failures we have had were when the tool had to be stopped in the cut. Sudden shocks break tungsten-carbide tools." (3) "Set-up called for three roughing tools at one time. It was necessary to remove one tool for lack of power after the belt and clutch were tightened as much as possible without injury to the machine." (4) "On the full-automatic lathe, the tools were used in conjunction with a follow rest and the work was driven by means of serrated dogs. Any slight slipping of the work or misalignment of it while being inserted or ejected from between centers chipped the cutting edge, and it seemed almost impossible to get a full run from a tool." (5) "The machining of malleable-iron and brass wedge gate-valve disks has been unsuccessful owing to considerable vibration when running at the proper speed. Although the floor under the machine was strengthened and an entirely new machine installed, considerable vibration still existed and resulted in chatter." (6) "Tried tungsten-carbide tools and found that the first requirement of their successful use is rigidity of the machine tool. Since we have practically no machines in our plant rigid enough for the use of these tools, we abandoned further experiments."

A condition reported by two companies regarding the wear of the front face of the tool, thus reducing the clearance angle, is stated by one of them as follows: "Had no particular success on tough steels. There seemed to be a pressure on the nose of the tool which resulted in an abrasive action which rapidly wore away the front clearance."

Another unsatisfactory condition reported by three companies was the wearing of a groove on the top of the tool directly back of the cutting edge. One of the companies stated that this occurred when machining nickel-chromium-steel forgings and caused the cutting edge to break. This difficulty was obviated by grinding a groove at the point where it wore, thus reducing the compression of the chip as it was being cut from the work, and consequently reducing its pressure on the top of the tool.

L—Suggestion for Design Changes of Machinery to Make Possible the Most Efficient Use of Tungsten-Carbide Tools

Practically all of the experiences reported indicate that this material possesses possibilities for the improvement of machining practices far beyond those already attained, provided further improvement is made in the material and in the tools and machines to withstand the more severe service to which they will be subjected. There is still much to be done, especially in the design of machines, and a consideration of some of the suggestions which have been submitted for their improvement would not be amiss. The suggestions are as follows:

1 Utmost rigidity of the frame, driving shaft and spindle, tail stocks, or other members subject to strain is essential in order that deflections shall be extremely small.

2 Large-capacity ball bearings, preferably preloaded, or adjustable roller bearings of precision quality, should be used for spindles to withstand heavy loads and to eliminate bearing clearances or reduce them to a minimum.

3 Considerably higher speeds are obviously necessary.

4 Greater power should be provided, with a large allowance for overload so that machine will not stall when cutting.

5 It is important that feeding mechanisms be designed to eliminate jumping due to the building up and sudden release of pressure on tools.

6 Tool holders should be heavier and designed to eliminate the overhang of tools, and the method of clamping tools in holders should be improved to insure rigidity.

7 Better provision should be made for handling chips and for protecting operators from flying chips.

M—Any Additional Information That Is Available, Such as the Attitude of Labor With Respect to This Material, the Difficulty of Training Operators in the Use of It, Difficulty of Tipping Tools, and the Like, Would Be of Value

The replies received contain much valuable information and many terse comments pertinent to the subject of tungsten-carbide applications, and this report would be incomplete without the inclusion of some of them. The following are typical:

1 "After the operators become familiar with the possibilities of tungsten-carbide tools, they are reluctant to go back again to high-speed steel."

2 "We have been conducting a lot of tests, some successful and some not. We started out using just one or two tools on different machines, obtaining various results. We finally completely equipped one 24-in. Bullard turret machine with a set of 13 tools which covered practically all of the work which we were doing on this type of machine. This was at a cost of $652 as against a cost of $43 for high-speed tools of the same size and number. We have kept comparative costs as against high-speed steel, and find that our savings average approximately 31 per cent in time over that of high-speed steel."

3 "Tungsten-carbide tools have not progressed beyond experimental stages, though we have been working with the material ever since its introduction. We have not found it satisfactory as a cutting medium in our production work, where we are called upon to machine high-carbon chrome-steel forgings of an analysis similar to S.A.E. 52,100 annealed to a Brinell hardness of 170. In all trials of tungsten-carbide tools on this material it has proved less satisfactory than cobalt high-speed steels.

"We have found tungsten-carbide tools exceedingly satisfactory on cast iron, where we have been able to take very increased depths of cut at higher cutting speeds.

"We note an interesting condition in the use of tungsten-carbide tools on either high-carbon chrome or low-carbon steels:

namely, that if we introduced the tool into the work carefully, a continuous cut could be taken at high surface speed and corresponding coarse feed, without any detriment to the tool so long as the tool was not removed from the cut; but when the tool was removed, a small piece of the cutting edge remained in the work. This was demonstrated any number of times, and so far we have found no way of overcoming this difficulty.

"In general, we believe that standard machines made within the last three or four years are sufficiently powerful and have the necessary speed range to use tungsten carbide on work to which it is adapted. We have every confidence in the possibility for increased production and savings in the cost of machine operations by the careful application of this material."

4 "Generally speaking, we have found it impractical to adopt tungsten carbide as a cutting material for general use in our shop. While greatly increased speeds and feeds are possible on certain jobs, the overall saving on most of our work does not justify the high cost and frequent breakage of the tools. The reason for this condition is that the actual cutting time is not a very large part of the total time, because we subdivide cuts wherever possible and because our quantities are not very large. We also have to machine parts which are too frail to stand any more speed or feed than is obtainable with a high-speed-steel tool.

On the other hand, we have found tungsten carbide to be very useful in cases where we have had to machine hard or abrasive materials such as chilled cast iron, hardened steel, very hard bronze, sandy steel castings, or other materials which high-speed-steel tools would not cut at ordinary speeds. In such cases the time saved seems to justify the high cost of the tools. For the machining of soft materials such as cold-rolled steel and gray cast iron in small or medium-sized quantities, the present cost of tungsten carbide seems entirely too high to make it commercially practical."

Conclusion

Tungsten-carbide tools have been on the market for about a year and a half, but their use on production work is very limited as yet. A year ago it was thought that the development of tungsten carbide with respect to material and tools would progress much more rapidly than improvements would be made in adapting machines to the use of this material. This does not seem to have been the case. Improvements in the quality of the material, and in the efficiency of the tools and machines, seem to be advancing together. The improvement of the machines, however, is a large undertaking, and we may expect important changes in design for some time to come. A large amount of evidence proves that for certain classes of work, tungsten-carbide tools can be used with considerable economy on old-style machines provided they are in good condition. These tools are being experimented with by a large number of machine-tool users in an endeavor to adapt them to present machine set-ups. We need not expect that the transition from the use of old-style machine equipment to the use of highly developed machine equipment due to the more general adoption of tungsten-carbide tools will be unduly rapid.

The technique involved in the use of tungsten-carbide tools is quite different from that involved in the use of steel tools, and it will take some time to train shop people in the proper methods of handling, grinding, and setting up tools and machines. The development of this technique is rather expensive, but if the initial applications are made where appreciable saving can be effected, the cost of further and more difficult applications will be compensated for, at least to some extent. A wide demand for machine equipment from which maximum efficiencies can be obtained with the use of tungsten-carbide tools will undoubtedly develop with experience gained from applications on present equipment.

The Subcommittee extends thanks to the National Machine Tool Builders' Association for assistance rendered in the distribution of letters and questionnaires, and also to the many companies who responded for their well-prepared replies.

[The complete report concludes with the questionnaire.—Editor.]

The Transmutation of Matter

THE idea that one metal could be transmuted into another first arose among the Greeks in Alexandria in the first few centuries A.D. and spread through Europe in the Middle Ages. The search for the Philosopher's Stone, by the help of which one metal could be converted into another, was pursued with confidence and hope under the direct patronage of princes and rulers, who hoped in this way to restore their finances. Although the evidence in its support was meager and doubtful, this idea of transmutation was very widespread, for it not only accorded with the desires of man, but was supported by the philosophic conceptions of Aristotle.

The proof, in 1903, that the heavy radioactive elements were undergoing spontaneous transformation with the emission of new radiations of a powerful type was an event of great importance, but it was soon shown that this radioactive property was confined to a few elements only, and that the great majority of the ordinary elements appeared to be permanently stable. In the meantime there was a rapid increase in our knowledge of the structure of atoms, and it became clear that in order to produce a permanent change in an atom, it was necessary to remove, or add, a charged particle to the minute charged nucleus which governed the properties of an atom. In 1919 Rutherford showed that some of the nuclei of the atoms of nitrogen could be transformed by bombardment with the swift α particles emitted by radium. Subsequently, Rutherford and Chadwick found that a number of the lighter elements showed a similar effect, and in all cases a swift proton was found to be emitted in consequence of a violent collision between an α particle and the atomic nucleus. Our evidence indicates that in the case of nitrogen the α particle is captured during this process and the mass of the resulting atom is greater than before. These effects manifest themselves on a very small scale and in general only about one α particle in 100,000 comes close enough to a nucleus to effect its disruption.

Transformation of an atom would occur also if an electron could be forced into a nucleus. In recent years, numerous experiments have been made to change mercury into gold and lead into mercury by means of intense electrical discharges, but there is no certain evidence that any transmutation occurs by this method. There appears to be little doubt that, if sufficiently energetic atomic projectiles were available, many of the elements could be transmuted, but only on a minute scale.

Apart from the radioactive bodies, it now seems clear that a large amount of energy must be applied to produce a disruption of the nuclei of the ordinary elements. The old idea that a new source of energy could be tapped by transformation of the ordinary elements now seems untenable. There remains, however, one interesting possibility. If hydrogen nuclei—protons—could be made to combine to form a nucleus of helium, an enormous amount of energy should be emitted during the process. Unfortunately, there is as yet no evidence that such a combination could be produced under conditions available in our laboratories. There seems to be clear evidence that the processes of disintegration and reformation of the atoms of the elements must be occurring in hot stars, but as yet we have no idea of the conditions requisite for such changes.—From a lecture delivered at the Royal Institution by Sir Ernest Rutherford, and published in *The Engineer*, April 4, 1930, p. 387.

Symposium on Aircraft Materials

Significant Portions of Some Papers Read at the A.S.T.M. Meeting at Atlantic City

AT TWO sessions on Friday, June 27, of the meeting of the American Society for Testing Materials at Atlantic City, New Jersey, representatives of the engineering side of the aircraft industry met together for a remarkably frank discussion of the many phases of the industry having to do with materials of construction.

As pointed out by Horace C. Knerr, president of the Metallurgical Laboratories, Inc., Philadelphia, Pa., "there is perhaps no industry in which an exact knowledge of the properties of materials of construction is more necessary. Each individual part must be completely dependable and yet must be reduced to the lowest possible weight. Factors of safety must be ample, but factors of ignorance negligible. It is essential to know just what service each type and class of material can be depended upon to render, and to insure that each unit and element will perform at par. This calls for accurate and complete engineering data, adequate and standardized specifications, and rigorous and thorough testing to insure that requirements are met."

Ferrous Metals

Ferrous metals were discussed by J. B. Johnson, chief of the Material Section, Matériel Division, U.S.A., Wright Field, Dayton, Ohio. The part of particular interest to mechanical engineers is that dealing with sheets and strips. The airplane designer uses these for the more important and highly stressed members, the fabrication of which often requires severe bends in any direction. When steel mills were asked at first to produce such sheets there was a good deal of hesitation, but the work was undertaken and metallurgists have succeeded in producing a sheet which has equal strength or bending properties no matter what the angle is of the axis of the specimen to the edges of the sheet. In the case of carbon-steel sheet the composition has been fixed so that the minimum tensile strength after welding, (i.e., in the area annealed by welding) shall be not less than 50,000 lb. per sq. in. and for the chromium-molybdenum sheet 80,000 lb. per sq. in.

"The carbon-steel strip," said Mr. Johnson, "is made from hot-rolled strip which is severely worked by cold rolling annealed to obtain an equiaxed grain and finally given a light draft for surface finish. The alloy sheet may be soft-annealed and finished by cold rolling or simply hot-rolled and annealed for high tensile properties.

"Strip steels of high carbon content are used in both the annealed and tempered condition, principally for springs."

On the subject of wire, he spoke as follows: "The hard-drawn tinned wire which was used for tension members has been largely replaced by a cold-reverse-rolled tie rod of elliptical, round, or square cross-section. This tie rod is manufactured from a cold-drawn circular wire containing from 0.40 to 0.55 per cent of carbon with a minimum tensile strength of 125,000 lb. per sq. in. The reverse rolling raises this to 150,000 lb. per sq. in. in the reduced section. Similar wires of corrosion-resistant chromium-nickel steel were raised to 200,000 lb. per sq. in. in the reduced section."

Light Alloys

Light alloys for aircraft were discussed by representatives of the Aluminum Company of America.[1]

One of the most interesting materials in this field is Alclad 17ST which consists of heat-treated and etched duralumin covered on both sides with a thin surface layer of high purity aluminum, alloyed and integral with the core. These surface coatings protect the 17ST from corrosion not only on the unbroken surfaces but also, because of the electrolytic action, at the edges and other places where small areas are exposed.

Alclad alloy 17ST has the interesting property of being self-damping as regards vibration. The soft pure metal on the surface is stressed beyond its yield point by small deflections and this tends to retard the back swing, thereby providing a marked damping effect. The advantages of this in aircraft work where thin sections are used become readily apparent.

In reply to a question a representative of the Aluminum Company of America stated that while Alclad tubing had not yet been produced commercially, attempts were being made to produce it, among other methods, by the cupping process.

It is stated that alloys are usually sand cast and that relatively little use is made of permanent-mold or die castings in aluminum alloys in aircraft work. The properties of permanent-mold castings are higher than those of sand castings for the same alloy.

Considerable use is being made of magnesium castings for aircraft engine parts. The most common alloy used is designated No. AM 7.4, containing approximately 7 per cent aluminum, 0.4 per cent manganese, and 92.6 per cent magnesium. The alloy may be used in the as-cast condition but is more frequently used in the heat-treated condition. Its physical properties are as follows:

Condition	Average tensile strength, lb. per sq. in.	Average elongation in 2 in., per cent	Endurance limit (rotating beam), lb. per sq. in.	Brinell hardness number
As cast	24,000	6	8,500	45
Heat treated	33,000	8	10,000	50

Note: The results given above are obtained from a standard test bar 1/2 in. in diameter, cast in sand molds without chill or artificial means of cooling and tested without machining-off the surface. Evidence indicates, however, that approximately the same results are obtained on machined specimens.

This alloy weighs about 113 lb. per cu. ft. Castings made of it are therefore approximately one-third lighter than aluminum-alloy castings and thus result in a decrease in weight of one pound in every three as compared with aluminum.

Textiles

W. E. Emley,[2] speaking on aeronautical textiles, said, among other things, that the design of aeronautical textiles had reached, and sometimes surpassed, the limit of our ability to handle cotton. "Further development," he continued, "depends upon our finding how to make a fabric having greater strength with less weight. Good balloon cloth has a strength-weight factor of 20; that is, the strength in pounds per inch of width (40) is 20 times the weight in ounces per square yard (2). This is about the best that has been done in commercial production with home-grown cotton. Cotton produced elsewhere (notably Egypt) has a longer and softer fiber, which can be used to produce a fabric having a slightly greater strength-weight factor. Here also we are handicapped by the fact that few mills in the United States are equipped to spin the very fine yarns (120's or finer) which are

[1] R. L. Templin, Chief Engineer of Tests, F. V. Hartman, Research Mechanical Engineer, and E. C. Hartmann, Research Structural Engineer, Aluminum Company of America, New Kensington, Pa.

[2] Chief, Division of Fibrous and Organic Materials, U. S. Bureau of Standards, Washington, D. C.

required. While an industry might be built up on imported raw cotton or imported yarn, even with these it is not now possible to improve very greatly on good balloon cloth. For a strength-weight factor of 29, such as was formerly required for parachutes, we must resort to silk.

"Cotton yarn has only about 20 per cent of the tensile strength of the fibers of which it is composed. If some method of improving this 'spinning efficiency' could be devised, it would be a great boon to aeronautical designers, as well as to the cotton industry."

PREVENTION OF CORROSION

Based on information supplied by leading aircraft manufacturers, as résumé of present commercial practice on corrosion-prevention methods in use has been prepared. The survey shows that the Army and Navy requirements are doing a great deal to bring about uniformity in commercial practice.

"With but very few exceptions," said H. S. Rawdon,[3] "electroplating of all steel structural parts is the rule, the size of the parts used being the principal limiting factor. However, plating is expressly forbidden on hollow parts in which the plating solution may be entrapped and retained because of difficulties in draining. Both zinc and cadmium plating, deposited directly on the steel, are used, the preference being apparently somewhat in favor of cadmium. In one case, however, the substitution of dip-galvanizing on steel fittings for a hydroplane to replace cadmium plating on account of the lack of protection was reported. The quality of plated coating is insured by the requirement, in Government specifications, that such plated articles must withstand an exposure of 100 hr. in the 'salt spray' without a breakdown of the coating such as would be shown by rusting of the steel base. According to the U. S. Army Air Corps requirements the zinc coating should be not less than 0.001 in. in thickness, an average thickness of 0.0015 in. being desired. The cadmium coating should be not less than 0.003 in. in thickness. It may be inferred, therefore, that coatings whose thickness is equal to the minimum allowed in each case will successfully withstand an exposure of 100 hr. in the salt spray. The threads on threaded parts which are zinc-plated are undercut, usually 0.002 in.; this is not necessary if cadmium plating is used.

"The methods used for protecting the inside surfaces of tubular steel parts are practically the same throughout the industry. Closed steel tubular members, such as fuselage frames, are filled with hot (approximately 160 deg. fahr.) raw linseed oil under slight pressure and allowed to drain thoroughly. The holes, drilled for the purpose of filling and draining, are then tightly sealed by special plugs screwed securely into place. This procedure is, of course, carried out after all operations involving heating have been completed. The use of a hot 'rust preventive' for this purpose as an alternative for linseed oil was reported in a few cases. For protecting the inner surface of open-end tubular parts, such as struts, braces, aileron bars, and similar members, the treatment just described is not used. An oil which will set more rapidly than linseed oil may be used instead. The use of such an oil on both interior and exterior surfaces, in place of a primer, was reported by one manufacturer. In most cases, however, a primer such as is used as the first coat on internal surfaces was mentioned in most of the replies as the means used for protecting the inside of the open-end tubular steel parts. (The same method is applied to duralumin tubing.)"

Commenting on the protection of aluminum and aluminum-alloy parts, Mr. Rawdon said: "There is less uniformity in the methods for the surface treatment of aluminum than for steel. The Navy practice, as represented by the Naval Aircraft Factory, is to apply the anodic-oxidation process to all parts whose size will permit, a 3-per-cent by weight aqueous solution of chromic acid being the electrolyte steel. The process is not applied to alloys having a copper content greater than 5 per cent. The Naval Aircraft Factory has not found the anodic treatment to be applicable to aluminum-alloy castings in general however, on account of the variable shape and relatively large size."

The Jirotka process is used for the first treatment of aluminum fuel tanks. This process consists in the formation of a very uniform and thin surface film, presumably oxide, by immersion in a certain solution. The surface treatment of aluminum is intended only as a preliminary one to be followed by a series of coatings.

AIRCRAFT FINISHES[4]

During 1925 and 1926 the author conducted a series of tests, in cooperation with the Bureau of Aeronautics, to determine the effect of various doping schedules upon airplane fabric surfaces. It was noted in these tests that whenever acetate dope was used for the priming coat, lower tautness was generally evidenced although good strength was developed. Whenever nitrate dope was used for the priming coats, good tautness was shown and satisfactory strength obtained. In fact, the whole series of tests indicated that when nitrate dopes were applied and properly protected from light by aluminum-pigmented outer coats, the underlying coats of nitrate dope were not broken by sunlight, the strength of the fabric was maintained, and excellent tautness was effected. Dopes pigmented in colors other than aluminum gave satisfactory service, but they were usually of greater weight.

Aluminum-pigmented dope presents such a rough surface that it soils very quickly and picks up grease and dirt that cannot readily be removed from wing surfaces, even when scrubbed. For this reason, air-station mechanics desire a smooth, washable surface that can readily be cleaned. To accomplish this two thin coats of clear spar varnish may be applied over the aluminum-pigmented dope. If the varnish is of fairly light color, it does not cut down the reflectivity of the surface to any marked degree. It is true that clear varnish is not durable over extended periods of exposure, and when used should preferably have sufficient pigment to give protection against light.

Properly compounded nitrocellulose-lacquer coatings are now being applied to the top-side wing surfaces. The chief disadvantage of lacquer coatings on fabric is lack of flexibility. However, as yet very little cognizance has been given to the newly developed lacquer-varnish coatings. These coatings usually contain nitrocellulose properly compounded in solution with phthalic anhydride-glycerin resins. They are quick drying in nature and produce finishes which are highly water resistant. Their durability is exceptionally good. Exposure usually results in a chalky film which is ideal for repainting. It is believed that these new type lacquer varnishes, when pigmented, would make excellent coverings for the top sides of the wing surfaces and for general use on other plane equipment.

Corrosion of steel and iron fittings on aircraft is apt to be very serious unless the most durable types of protective coatings are applied. Whenever practicable it has been recommended that steel parts except tubing be cadmium plated. Tubing usually is not, because of the difficulty of washing out the interior parts after the plating operation.

While tubing is generally pickled to prepare the surface for the application of protective coatings, sandblasting of all other metal surfaces is probably desirable. Wherever pickling is done,

[3] Chief, Division of Metallurgy, U. S. Bureau of Standards, Washington, D. C.

[4] Condensed from a paper entitled "Notes on Aircraft Finishes," by H. A. Gardner, Director, Institute of Paint and Varnish Research, Washington, D. C.

the acid should be well drained from the tubes and the tubes rinsed thoroughly in cold water and then for several minutes in a bath containing hydrated lime in order thoroughly to neutralize any traces of acid which may be left in the tubes. The use of lime after pickling metal surfaces which are to be painted was found advantageous on several hundred large-size steel and iron panels which the author used in the series of paint tests conducted in cooperation with the American Society for Testing Materials in 1910 at Atlantic City. After this treatment, the metal plates were found to be in an excellent condition for painting at the time they were removed from the lime storage boxes.

Duralumin has a very high coefficient of thermal expansion as compared with steel and certain types of quick-drying coatings that would be suitable in steel surfaces may not be sufficiently distensible for use in duralumin. Similarly it has been found that coatings which stand up well on duralumin may not always function efficiently on steel. The author refers to his own tests in this connection and an inspection of an old Junkers plane which, for experimental purposes, had been placed upon the sand dunes at Hampton Roads with some coatings applied to the top-side wing surfaces. Aluminum spar varnish stood up fairly well and so did lampblack in oil; the other materials failed. Some of the results of these tests are as follows:

It is apparent that linseed-oil paints, because of their great flexibility, are exceptionally well suited for the protection of duralumin. Because of the low weight of such coatings when pigmented with black carbon pigments or with aluminum powder, it is believed that where weight is a factor, such types of paint are well suited for the purpose. Aluminum powder greatly retards the drying of raw-oil paints. The addition of basic white pigments or the use of boiled linseed oil is suggested.

As a result of these tests, the author later designed a primer for duralumin, which consists of zinc chromate and red iron oxide, two pigments which showed excellent results in the above-described tests, finely ground to a stiff paste in linseed oil to give elasticity, and then reduced with varnish and drier to a thin consistency so that when applied to duralumin surfaces a fairly quick-drying coating would result. This formula was later adopted by the U. S. Navy Bureau of Aeronautics and has been in successful use for a period of several years. It will withstand baking at a temperature of 250 deg. fahr. for a period of one hour with satisfactory results, and when so treated produces a semi-dull, elastic film over which pigmented oil varnish coatings or nitrocellulose lacquers may be applied. Fortunately a rather broad-minded policy has been developed in regard to duralumin primers. The necessity of not retarding contractors in production schedules by the use of slow drying primers is a matter that has often been given proper consideration by the governmental authorities.

While it is probable that aluminum and duralumin will not deteriorate very seriously on land planes, rapid corrosion may take place on seaplanes in warm climates and where contact with salt water is frequent.

It has also been brought out that aluminum-bituminous paints have proved satisfactory over anodically-treated aluminum alloys, but these preferably should be used on surfaces that are not to be exposed to sunlight. These aluminum-bituminous solutions have also been used satisfactorily for the interiors of pontoons where much corrosion is apt to occur. This type of coating is very water resistant and suitable where it is not exposed to the sun. In strong sunlight, alligatoring, dulling, and destruction of the film may take place in brief periods. One disadvantage of bituminous paint is its solubility in gasoline. For this reason, gasoline-resistance coatings, made usually with shellac, have been employed on certain surfaces which may come in contact with gasoline.

MATERIALS OF CONSTRUCTION IN AIRCRAFT ENGINES

R. R. Moore,[1] in a paper entitled "Materials of Construction in Aircraft Engines," covered briefly the various steels, bronzes, and brasses, and light alloys that are most commonly used in the construction of aircraft engines. Excerpts from the paper follow.

The total weight of a radial air-cooled engine is made up of about 45 per cent aluminum alloys, about 3 per cent bronze, and the remaining 52 per cent steel. There is a negligible amount in rubber, felt, vellum, cork, etc. The relatively large percentage of light alloys used in aircraft engines accounts, of course, for their light weight. The purpose of using light alloys is not only to cut down the dead weight of engines, but also to reduce the weight of reciprocating parts.

In some radial engines the main crankcase section is a forging made from alloy L (silicon 0.90, aluminum 0.60) which is then heat-treated. This, of course, gives a much stronger part. However, the modulus of elasticity of the forged and heat-treated alloy L and the cast alloy C (copper 4.5, silicon 0.85) are practically the same. This means that under the same stresses below the elastic limit the deformation is practically the same in each case. For this reason any gain in weight obtained by decreasing the wall thickness of the forged crankcase is done at the expense of stiffness. The forged crankcase, however, has the advantage of a higher yield point, which means that higher stresses can be endured without assuming permanent set as might occur in the case of occasional over-stress. Furthermore, the forging has greater ductility which will permit more distortion before cracks and ruptures are started. Unless forgings are used in a great quantity they are not cheaper than castings because of the high die costs which add considerably to the price of each forging when only a few are made. A disadvantage of the forged crankcase is the limitations of the designer to place bosses, passageways, grooves, etc., integral with the casting. A crankcase must be designed specifically for a forging or for a casting. One type of manufacture cannot be converted to the other without radical changes in design.

Rear crankcase sections of radial engines have also been made from a magnesium-base alloy I (magnesium 92.6 per cent, manganese 0.4 per cent, aluminum 7 per cent) which is considerably lighter than any of the aluminum alloys and has excellent physical properties. The susceptibility of magnesium alloys to corrosion has been greatly reduced by the use of magnesium of higher purity and the addition of special elements to the alloy. In designing parts to be made from magnesium alloys it should be remembered that the modulus of elasticity is only about 6,250,000 lb. per sq. in. as compared to a value of 10,250,000 lb. per sq. in. for the aluminum alloys. This means that the magnesium alloy is subjected to greater deformation under load. Experimentally various other parts such as crankcase sections, supercharger housings, and oil-pump sumps have been made of magnesium alloys.

The performance of steels is generally based on such properties as elastic limit, strength, hardness, ductility, fatigue, wearing quality, etc. However, these properties are only a few of those that contribute to the successful application of metals. Due consideration must also be given to such factors as uniformity, depth of hardening, tendency to warp, hardening range, forgeability, machinability, etc. All of these properties are inherent in the alloy and contribute to its success or failure in performing the functions for which it is intended.

A common method of selecting steels for certain parts has been to adopt the same steel as used in a similar part in some other engine. The defect in this system is that no two engines are

[1] Chief Metallurgist, Wright Aeronautical Corporation, Paterson, N. J.

exactly alike and a steel that proves successful in one engine may not prove successful in another of apparently similar design, because the service conditions to which the part is subjected are not as nearly alike as is commonly supposed.

The author gives a table listing the various steels used in aircraft engines. They are practically all of the S.A.E. types.

The nickel steels similar to S.A.E. No. 2330 or with somewhat higher carbon content find considerable use in bar form for such parts as bolts, studs, nuts, small shafts, and in the form of forgings for rocker arms and small connecting rods which do not require great hardness. This steel has an advantage for such small forgings because it forges well and is not readily overheated. It is not generally used for large forgings because it lacks penetration in hardening. The high-nickel steel known as S.A.E. No. 2512 is a case-hardening steel and is rated as one of the best for such applications as gears and highly stressed parts which require a very tough core and a hard surface. The advantage of this steel is that it gives a very tough core and hard case with good grain refinement of both after a single quench from about 1425 deg. fahr. Because of the comparatively low quenching temperature it is often used on complicated parts that are prone to warp during hardening.

Wire is used for miscellaneous springs throughout the engine. Some of these springs are subject to small stresses and function only intermittently. They may be made from ordinary carbon-steel spring wire V. When a high-quality spring is desired it is made from music wire or chromium-vanadium spring wire S.A.E. No. 6150. Valve springs which are one of the most important parts of the engine and are continuously subjected to repeated stresses are made from either the chromium-vanadium spring wire S.A.E. 6150 or music wire. Both of these classes of wire have proved satisfactory in aircraft engines.

In connection with the matter of springs the question was raised in the discussion as to why chrome-vanadium springs are preferred in the United States, while silicon-type alloys are used in Europe. One of the explanations given was that European engineers were not familiar with the properties of chrome-vanadium springs.

Failures of Aircraft-Engine Parts and Causes Thereof

A paper entitled "Failures of Aircraft-Engine Parts and Causes Thereof" by Thos. T. Neill of the U.S. Bureau of Standards (Jun. A.S.M.E.) is based upon information obtained from tests made under conditions specified in the Air Commerce Regulations and the facts are of value only under comparable conditions. Since the paper was written the testing facilities of the Bureau of Standards have been very materially increased.

The block tests made at the Bureau of Standards, which conform in general to the corresponding Army and Navy tests, comprise (1) a 50-hr. endurance test and (2) a power-curve test. The former is run in ten 5-hr. periods, the first of which must be at full throttle at a speed at least equal to the manufacturer's rated speed. The average power developed during this period is used as a basis for the rating. During the remaining nine periods the engine is run at approximately 97 per cent of the rated speed, giving a horsepower not less than nine-tenths of the rated horsepower. Minor repairs and replacements are permitted between periods and a maximum of three forced stops is allowed during the test. These latter require additional specified penalty runs.

The number of materials suitable for the various parts of similar types of aircraft engines is relatively small; and although it cannot be said that really suitable materials are always used, the different manufacturers do not seem desirous of showing very much originality in this respect. There appear to be, however, numerous possible satisfactory variations in design, many of which have value from the point of production or sales if not of operation, and hence the engines submitted for test have shown considerable difference in this respect. The result has been that even though material and design are interrelated, more failures may be charged to the latter than to the former.

At the same time the author remarked that things are getting better and more engines are passing the test now than was the case formerly. The main cause of failure of a large number of engines during the tests is lack of sufficient development work by the manufacturers. The valve assembly is one place where a particularly large number of failures have occurred. This is partially due to the excessive amount of trouble with springs, as well as to bad manufacturing practice elsewhere. For example, some manufacturers have made rocker arms from bar stock, and others have used a single die, and then made rights and lefts by twisting. Both of these practices have resulted in failures. Many instances of poor design have also been found ranging all the way from improperly designed sections to poor tappet-adjustment locking devices. Failures of valve springs are very common, particularly where single springs are used. Where multiple springs of the conventional wire-coil type are used very little trouble has been caused by a broken spring's becoming entangled with the others of the same group.

The failure of a valve is extremely serious and frequently results in completely wrecking the engine. Piston failure is frequently caused by the breakage of a valve in engines of the in-head type. If the stem breaks near the upper end a suitable safety device may save the engine. In the cases noted by the author, however, the safety devices were of no value.

Cylinder failures have been more common than might be expected. In two cases the bosses or flanges provided to secure the cylinders to the crankcase have broken. Cracks occasionally develop in the cylinder head and overheating due to insufficient cooling-fin area has been determined definitely as the cause in one case. Poor heat treatment and inferior material were probably the major factors in another case where several aluminum-alloy heads failed.

The weaknesses which have been noted are for the most part those which should have been found and corrected during the manufacturers' development work. All of the engines submitted are supposedly ready for production and sale. Out of the first twelve engines tested only two passed; the builders of the others either resumed their experimental work or discontinued activity in this line. The protection afforded the flying public, as well as those over whom these engines might have flown, is very obvious.

This test work has also resulted in the building of improved commercial engines, thus helping the manufacturers to create new public confidence in the industry. Most of the engines recently submitted have passed the test, whereas formerly the reverse was true, although the test requirements have gradually been made more rigid.

The best of engines must not be abused. Those which have received Approved Type Certificates from the Department of Commerce, as listed in the Air Commerce Bulletins, are approved for certain speeds, and for use on fuels the anti-knock properties of which should be equal to or exceed given values. If these conditions are not fairly met, new failures not encountered on the test stand may be expected.

Welding

The subject of welding was partly covered in a paper on "Metal Joints in Aircraft Construction," by T. Watson Downes, metallurgist, U. S. Naval Aircraft Factory, Philadelphia, Pa. Some quotations from Mr. Downes' paper follow.

Satisfactory gas and arc welds of the usual aircraft construction

steels are accomplished with a good grade of steel welding rod of the following composition: 0.06 per cent carbon, 0.15 per cent manganese, 0.04 per cent each of phosphorus and sulphur, and 0.08 per cent silicon (all maximum).

The straight carbon and chromium-vanadium structural steels which have been used in the manufacture of airplanes are readily welded but for several reasons are being replaced rapidly by chromium-molybdenum steel of the composition known as S.A.E. No. 4130X, one reason being its excellent welding properties and the high strength which can be developed by heat treatment. The welding of nickel steels should be avoided whenever possible because of the relatively inferior properties of welded joints thereof. As a rule, the practice of welding together unlike steels is to be discouraged because of the usual difficulty of suitably heat treating after welding to fully favor both steels.

Failure of untreated, undressed butt welds of good quality S.A.E. steel No. 4130X, using either low-carbon steel or parent metal as a welding rod, usually occurs about one-half inch from the weld, from 85,000 to 105,000 lb. per sq. in. tensile strength with an elongation in 2 in. of 3 to 7 per cent being developed in tension. Normalizing moderately improves the properties after welding. After heat treatment involving quenching and tempering, strengths up to 130,000 lb. per sq. in. in tension for butt welds of sheets and tubes 0.035 to 0.188 in. thick made with low-carbon rod, and up to 180,000 lb. per sq. in. for those made with parent metal, have been previously reported. Welds made with low-carbon steel are in general more reliable and more uniform than those made with alloy steel and are therefore preferred. Aluminum and its strong alloys can be welded by the gas method in somewhat the same manner as is used with steel but are under certain conditions subject to cracking. A highly satisfactory flux is said to be that of the U. S. Navy Specification No. 51F2a. Its composition is as follows:

Sodium chloride	32 per cent
Potassium chloride	24 per cent
Lithium chloride	24 per cent
Sodium fluoride	20 per cent

Welded aluminum sheet has a tensile strength of about 10,000 lb. per sq. in. Welded joints of $1^1/_4$-per cent manganese-aluminum alloy sheet from 0.032 to 0.051 in. in thickness develop a tensile strength of from 18,000 to 20,000 lb. per sq. in. with an elongation in 2 in. of 7 to 15 per cent. Brazing, soldering, including silver soldering, and riveting are also briefly discussed.

A joint paper by three authors[6] discussed "Procedure Control in Aircraft Welding." This is a paper of a highly practical character and aroused a good deal of discussion. The difficulty in testing a welded joint without destroying it emphasizes the need for control in making welds. The Sperry apparatus originally used for detecting transverse fissures in rails has been tried for welds with promising results and testing with the stethoscope has received much favorable comment. So far as is known, however, neither of these methods has been extensively tried out on welds in thin tubular members.

Probably no welded structure must meet such rigid requirements for strength as the airplane, due to low factors of safety and the disastrous consequences of failure. The designer has at his disposal various materials with certain properties. He knows by means of stress analysis that if welded together in a certain way, they will carry the required load. His greatest problem is to be sure that the structure will have the computed strength. Procedure control for the welding gives him such assurance by reducing the human element in this process to the minimum.

In 1928 the U. S. Bureau of Standards started an investigation of the strength of welded joints in tubular members for aircraft. At this time there were no established rules of practice for aircraft welding which could be used as a standard of quality. It was considered of the utmost importance that all the welding done in this investigation be uniform and of good commercial quality, and it was realized that the test results would be of little value unless all factors affecting the strength of the joints were fixed and could be reproduced in commercial work. To insure these results it was decided that the welding be done under a procedure control especially prepared for aircraft welding.

The American Bureau of Welding appointed a committee which prepared specifications for oxyacetylene welding in aircraft. The procedure specifications have been published under the title, "Procedure Control for Welding Aircraft Joints. Report by Committee of American Bureau of Welding." These specifications cover gas welding only. The procedure specification for electric welding has not been prepared.

Although prepared specifically for the welding of the test specimens in the Bureau of Standards investigation, they could be adapted with some modification and additions to the welding of aircraft in production.

The authors tell what should be specified in procedure control in production and do not actually set up any welding code.

In the course of the discussion a question came up as to the causes of cracking in welding from molybdenum sheet of about $^1/_{16}$ in. thick. From the discussion it appeared that practically all the larger airplane builders ran into this kind of trouble at one time or another and that the only way to overcome it was by proper procedure control.

Horace C. Knerr's paper on "Heat Treatment of Aircraft Parts" was the cause of interesting discussion dealing with some of the factors which cause failure of parts. One of these was (using Dr. H. W. Gillett's terminology) "stress raisers" which one of the speakers described in even stronger words. These stress raisers occur in the form of tool marks, punch marks, sometimes stamped-in impressions of the name of the manufacturer, and act as a notch initiating local stresses enormously in excess of those which would have occurred if the surface of the material were not interrupted. Notwithstanding the fact that the malign influence of such factors has been known for a long time, they still occur even in aircraft parts. The paper itself is of a practical character and gives methods of operation of heat treatment for various parts considered most satisfactory by the author of the paper. Like all the other speakers Mr. Knerr pointed out the importance of direction and supervision.

"One-hundred-per-cent dependability is expected of aircraft parts. A single defective member among the thousands which comprise the engine and structure may cause disaster. Materials, processes, and inspection must therefore be such as to insure that each individual part fully meets its designated requirements. Heat treatment is only one of a series of interdependent factors which determine the properties of metal parts and their reliability of service. Competent metallurgical supervision should be exercised over all these factors if satisfactory results are to be assured in the finished product. Such factors may be classified as follows:

A Choice of materials and their correct use in design
B Specifications for purchase
C Inspection and test of raw materials
D Storage and identification of stock
E Fabrication:

[6] H. L. Whittemore, Chief, Engineering Mechanics Section, U. S. Bureau of Standards, Washington, D. C., Mem. A.S.M.E., John J. Crowe, Engineer in Charge, Apparatus, Research, and Development Dept., Air Reduction Sales Co., and H. H. Moss, Engineer, Development Dept., Linde Air Products Co., New York, N. Y. Assoc-Mem. A.S.M.E.

1 Machining, punching, etc.
2 Forming, hot or cold
3 Joining:
(*a*) riveting, (*b*) welding, (*c*) brazing, (*d*) soldering
4 Foundry practice
5 Heat treatment
6 Corrosion protection

F Inspection during fabrication
G Study of failures and defects to determine cause and prevent recurrence
H Investigation of new materials and processes to determine fitness for aircraft use."

Mr. Knerr also gave a list of practical suggestions which if followed should reduce rejections in final inspection. Some of the recommendations may be easier to make than to follow. This applies, for example, to suggestion No. 10 which calls for "intelligence, care, and conscientious attention to instructions on the part of the heat treater."

Specifications and Materials Control

One of the features of the symposium on aircraft materials was the insistence of practically all of the speakers on the importance of knowing what materials should be used for every part of the complicated airplane structure, and of seeing, once the material has been determined, that it is used as it should be. This was one of the reasons why so much space and time was devoted not to the materials themselves but to the control of operations on them, such as welding, heat treatment, etc.

In a paper on "Specifications and Materials Control" by H. A. Backus,[7] the author points out that with the present types of aircraft the merit factor of strength divided by weight is most important so far as the structure is concerned. "There are two factors of ignorance which handicap designs through excess weight. The first represents the ratio between the actual applied loads or developed stresses and the calculated loads or stresses. With more accurate aerodynamic data and improved methods of calculation this factor will approach unity as a limit. The second factor of ignorance is represented by the ratio between the actual or developed strength and the desired or calculated strength. To decrease this factor safely requires complete knowledge and continuous control of materials and processes. If the airplane designer could be absolutely assured of complete uniformity in all materials of construction and in all manufacturing operations of these materials, he would find it possible and practicable to save considerable weight without changing the type of design or the specific strength of any materials. Wrought metals are relatively uniform, in comparison with castings, but a detailed inspection leads every metallurgist to the conclusion that all materials require careful watching."

The paper presents a discussion not only of aircraft specifications in particular, but the art of drawing up a specification in general, although in many other branches of engineering it may not be necessary to make the specification quite as elaborate and foolproof as is advisable to do, for obvious reasons, in aircraft.

Among other things the author recommends that a system of specification numbers be provided as a means of identifying even those materials and processes which are looked upon as ordinary or commercial.

"There is an important point in considering a material specification number as a stock classification number. Many of the Army and Navy specifications are so general in nature that they cannot be used by number alone to indicate without qualifications any one of the several kinds of grades of material which they cover. For example, Army specifications 57,136–8 for chromium-molybdenum steel sheet or strip specifies annealed material, but without indicating physical requirements in that state other than a bend test. It is also required that the material be capable of developing a tensile strength of 125,000 lb. per sq. in. with appropriate yield point and elongation after heat treatment. Much of this material is purchased in the normalized state, calling for 95,000 lb. per sq. in., minimum, in which condition it is sufficiently workable for general use. When used in designs at this strength no further heat treatment would be specified on drawings. Here, the Army specification number affords no means of fixing the strength of the material and there is therefore the possibility of using annealed material in production where normalized or heat-treated material was intended. It is necessary, therefore, to make a separate specification covering this type of steel when supplied at 95,000 lb. per sq. in. tensile strength. There are also instances where steels of different compositions and requiring different heat treatments are permitted under a given set of physical requirements. By assigning a number which will properly differentiate between varieties in chemical analysis and mechanical properties, a symbol for stock classification is arrived at which can be used on drawings and go through the production, inspection, stores, accounting, and purchasing departments with surprising convenience and without danger of confusion.

"In writing and interpreting specifications, due recognition must be made of (1) allowable variations from the desired normal and (2) the policy which determines the degree of quality control to be imposed. A specification implies that there is only one correct or preferred procedure, characteristic, or material. This is not invariably true and there are some specifications in which allowable alternates are all equally acceptable and should be expressed when there is no desire to distinguish between them.

"Experience has proved that it is unsafe and misleading continually to put faith in superficial methods of inspection, or even in inspection at source by the vendor or by the Army or Navy inspectors. Repeatedly, extra tests of a type indicated later have shown non-uniformity to exist in a lot where every one had expected satisfaction because tests by the sampling method have been acceptable. This is a serious matter where design is based on as close factors as must exist in aircraft construction."

This is followed by recommendations dealing with inspection and test requirements for purchased materials. Among other things the author emphasizes that it is so easy to assume that a lot of material is completely satisfactory that at times no effort is made to give the lot a careful re-check and to rely wholly upon the results of inspection at source or upon a few sample tests at destination. With more detailed inspection methods, however, facts are found which make it possible not only to reject material but also to correct the procedure and so improve the product. In airplane manufacture there is general agreement that quality is paramount, but there are many examples of unheeding or ignorant violation of the means by which quality control is accomplished.

The author then gives a list of specifications for various aircraft materials. As an illustration of the character of the specifications the following passage as to steel bars is cited. "All steel bars should be individually inspected and tested because (1) mixed lots are not unknown and are very costly, (2) defects which are reasons for rejection are more easily caught and more accurately estimated through a quantity of tests than by a single sample, and (3) items which may vary from bar to bar, such as pipes, seams, laps, and possible surface decarbonization, may be more definitely caught and segregated. The growing use of the deep etch tests is of real value and it well repays the initial trouble of inspection."

[7] Quality Supervisor, Metallurgical Laboratories, Inc., Philadelphia, Pa.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Cierva Autogyro Mark III

THE previous type of this craft turned out to be a good deal in excess of the estimated weight. The result was that the rotor was too heavily loaded and as the autogyro is fairly sensitive to relatively small changes, the performance suffered in certain respects. In the new machine the rotor size has been increased, reducing its unit loading and decreasing its speed of rotation to about 125 r.p.m. The writer of the article was present at a demonstration of the autogyro and states that the landing was amazing. When some 50 or 60 yards from the hangar the pilot pulled the stick back, the machine tilted back and settled down on a very steep path, touching the ground and coming to a standstill after about two revolutions of the landing wheels. The original article gives some constructional details of the plane. The blades are provided with hinges. Each spar has a double hinge of which the inner pin is horizontal and permits the blade to rise under the action of the lift, while the outer hinge pin is vertical and permits the blade to swing in a fore and aft direction in the plane of the blades.

Hitherto one of the arguments against the autogyro has been that, owing to the fact that the rotor continues to run and give lift after the machine has come to a standstill, there is risk of turning over on the ground. In fact, this has happened on more than one occasion. A brake has now been fitted by means of which the rotor can be stopped quickly and thus the risk of turning over should be materially decreased. As regards performance, the top speed of Mark II A is approximately 90 m.p.h. but it is estimated that in the new machine this figure will be increased to at least 95 m.p.h. The machine is able to maintain horizontal flight at 25 m.p.h., while the landing speed is very nearly nothing. (*Flight*, vol. 22, no. 19/1115, May 9, 1930, pp. 501–506, illustrated, *d*)

Reasons Most Air Lines Do Not Pay

ONE of the reasons for the failure of air lines to pay is the high cost of planes. This is due principally to limited production. Next there is the expense of providing buses for hauling passengers to and from the airports, although recently several large operators have eliminated free bus service so that the cost of transfer to and from airports is borne by the passenger. Furthermore the salaries of transport pilots are high and the operating cost of passenger planes is also high.

Some transport companies have tried to meet the situation by reducing fares so as to obtain capacity loads, but to the author it seems improbable that most passenger operators even under these conditions will be able to realize a profit with present equipment. For example, one of the systems concerned states that the cost of operating the ten-passenger planes on its line is approximately $1.42 per plane-mile and loaded to capacity these ships are earning but 50 cents a mile. Other air lines have brought their operating costs down to as low as $1.20 a mile. The author calls attention to the element of fear and adds that fear is often caused to some extent by the mystery that has surrounded accidents. Some companies have attempted to "cover things up" and to prevent newspapers from knowing and printing the true causes of accidents.

The author claims that the real crux of the problem of unprofitable air lines lies in the fact that no air-transport operator can succeed if he depends on passenger traffic alone. Except in rare instances human cargo is the most costly to handle and the air-transport operators should exert every effort toward building up freight business if they wish to place their lines on a paying basis. By freight is meant mail, express, baggage, perishable goods, and merchandise which is valuable and should be moved quickly. Railway express companies carry 39,000,000 lb. of "premium freight" every day. In the opinion of the author much of this would be sent by air if the rates were reasonable. (R. C. Marshall, Vice-President and General Manager, Thompson Aeronautical Corporation, in *Aero Digest*, vol. 16, no. 5, May, 1930, pp. 78, 238, 240, and 242, *g*)

Expert-Pilot Situation

IN AN ARTICLE entitled "The Men Who Fly the Planes," the author points out certain features of the situation as it exists with respect to pilots for transport planes. To receive a transport license a pilot must have had at least 200 hr. of solo flying, equivalent to perhaps 15,000 or 20,000 miles in the air. In addition to this he must be of good moral character, pass an exceedingly strict physical examination, and other examinations in engine and plane mechanics, fundamentals of meteorology, and air navigation. The regulations require that he must be at least 18 years of age (the average age of the pilots licensed in 1929 was above 18 but under 25 years). A few hundred of all the transport pilots in the country are more than 30 years old.

According to the chief pilot of one of the oldest and most successful air lines there are possibly only 200 pilots whom he would consider possessing the necessary qualifications to handle a transport plane and these 200 are not youngsters but old timers—war-time fliers and mail pilots. The conclusion to which the author comes is that the younger pilots are deficient in necessary caution. The older pilots will often fail to maintain schedules. Flying with them one may get to his destination a day late or three days late, but they will see that the passenger arrives safely. On the other hand, the author has flown in a big tri-motored plane with two confident young fellows into a thickening snow storm at night with a cabin full of passengers. Fortunately they flew between two storms and found their way safely to their scheduled airport. But it is not pleasant to think of what damage might have resulted if the storms had closed in and caught them "blind" with a dozen passengers.

In the early days of the air mail there were about forty pilots on the transcontinental run. Four of them, on the average, were killed every year. Conditions then were far more hazardous than they are today. Still, many of the more cautious and capable of those pilots of ten years ago are still "pushing mail" today.

The following illuminating data are cited by the author: Western Air Express, for example, has not had a single major accident with passengers since beginning operations between Los Angeles and Salt Lake City more than three years ago.

Boeing Air Transport, with a total of more than nine million miles flown in transport operations, have lost only one pilot. Incidentally, eight out of the first ten senior mail pilots of the country are with Boeing. The Stout lines, flying between Chicago, Detroit, and Cleveland, have set up a safety tradition with somewhat younger men, having carried more than one hundred thousand air passengers without a scratch.

The fact remains, however, that as air operations develop, with new lines opening up one after another, there are not enough experienced pilots. Young, skillful lads, capable of rounding out in time into weather-wise air captains, yes. Old timers who already have acquired wisdom and experience, no.

And in the meanwhile, except for the leading lines able to secure and hold their full quota of the limited old group pilots, the occasional air transport crashes will continue. (Myron M. Stearns in *World's Work*, vol. 59, no. 7, July, 1930, pp. 62–65 and 99, illustrated, *g*)

CORROSION

Foiling as Protection Against Corrosion

THE article deals chiefly with the application of foil (aluminum, lead, zinc, tin, or magnesium, copper, brass, nickel, and Allegheny metal—the last four only in narrow widths) by means of adhesives. Much trouble has been experienced in the past by trying to stick metals to materials having a different coefficient of expansion by means of hot tars and asphalts. The author deals in a general way with the development of adhesives and gives curves showing their characteristics. He adds, however, that all of these curves mean very little except to show what his organization has done. He does not give a composition of the atmospheres, however. (Harry F. Perkins, Technical Director, St. Louis Surfacer and Paint Co., *The Oil and Gas Journal*, vol. 28, no. 50, May 1, 1930, pp. 31 and 103, 6 figs., *d*)

ELECTRICAL ENGINEERING (See Marine Engineering: New Developments in the Application of Electric Machinery to Ship Propulsion)

ENGINEERING MATERIALS

Chemical Specifications of Steel

THE author of the paper, Director of Research of the United States Steel Corporation, claims in general that rigid chemical specifications are only partly justifiable in the purchase of the materials of construction which are used because of their physical or mechanical properties. In this case the purchaser is really interested in the structure of the material supplied, and need not care what elements are present provided that the material fulfils his requirements as to mechanical qualities, such as strength or ductility.

He bases his opinion, first, on the fact that chemical analysis usually does not go far enough to cover the material completely and only the quantity of certain materials present, such as carbon, sulphur, phosphorus, and manganese, are determined, while other materials, such as nitrogen and oxygen, are neglected, and yet may prove to have a material influence on the structure or properties of the metal. The difference which may result from a different distribution of a fixed proportion of a component as determined by analysis is also not shown by the analysis. The mode of distribution of non-metallic inclusions is likewise not shown. To illustrate this he cites the instance that whereas the upper limit of allowable sulphur is often set at 0.04 per cent, a committee of the American Society for Testing Materials concluded that sulphur may go as high as 0.077 per cent in plates and 0.06 per cent in rivets. The author finally claims that the piece of steel may be ruined by improper fashioning or heat treatment which does not affect its chemical composition.

In the discussion which followed, Dr. H. W. Gillett, Director of Battelle Memorial Institute, Columbus, Ohio, stated that "no specification is sacred and all specifications are human documents based on varying proportions of knowledge and of mere opinion. As knowledge advances, specifications should change accordingly. While the imposition of both physical and chemical requirements is being abandoned in principle by most specification-making bodies, at least when a finished product is in question, there are cases where both have to be specified. A firm making heat-treated parts for automobiles could utilize a dozen different steels by varying the heat treatment and in each case wind up with the desired properties. A choice of heat treatment, however, makes it necessary to adhere to a certain chemical specification only.

"In chilled-iron car wheels, a thermal test and a drop test to reveal fragility are imposed, and chemical composition is also required. But here what is wanted, besides freedom from fragility, is wear resistance. As there is as yet no simple, reliable test accepted for wear resistance, all that can be done is to fall back on indirect methods and specify something the user is not really interested in, because, in his experience, satisfactory wear resistance has accompanied the composition demanded.

"Even when we have knowledge, such as that cited by Dr. Johnston on permissible sulphur in rivet steel, we cannot safely extrapolate too far. Because a soft rivet steel is tolerant of manganese sulphide, is not a good argument for permitting high sulphur in a hard spring steel. It would probably be very dangerous, and, lacking direct proof, no one would be justified in arguing for a change in spring-steel specifications on the basis of research on rivet steel.

"Such research as that on permissible sulphur in rivet steel is very expensive. It has to be done under auspices admittedly free from any suspicion of bias, and by slow, unwieldy group action, in order to be accepted. Before there is any hope of widening the sulphur range in spring steel, some one will have to finance that phase of the work on sulphur and phosphorus." (John Johnston in paper before the American Iron and Steel Institute, New York, May 9, 1930; compare *Iron Age*, vol. 125, no. 21, May 22, 1930, pp. 1536–1537 and 1578, illustrated, *p*)

FOUNDRY

Casting Railway Bronze Bearings in Permanent Molds

THE paper here abstracted deals with the casting of bronze containing lead; and the prime motive in casting such bronze in permanent molds—in this case of cast iron—is the desire to increase the power of tin to hold in the lead by the chilling effect of these iron molds and thus to incorporate as much lead into these alloys as is compatable with the physical specifications.

From the point of view of friction alone large grain size is desirable. The experience of the railroads would indicate, however, that chilled cast bearings are given better service than the sand-cast bearings, although the latter have a coarser grain. This apparent contradiction is attributed to the fact that a railroad bearing is affected by other factors than friction alone. Also the usual higher lead content of the permant-mold-cast alloy probably does more than offset the advantage of larger lead grain in the sand-cast alloy. The author's own observation leads him to believe that the wearing qualities of bearings or bushings depend to an equal degree on the freedom from segregated lead or copper-tin alloys and metallic oxides, particularly those of copper, and on an even hardness throughout the bearing surface. In other words a homogeneous microstructure free from segregated

oxides is of first importance. The original article contains a table showing the chemical composition and the physical properties of sand-cast and permanent-mold-cast bearings which would indicate that the latter are better in permanent-mold castings.

At the present stage of development this comparatively new molding process is more or less shrouded in considerable mystery. The chilling effect of the mold does not embrittle brass or bronze as it does gray iron or high-carbon steel, the increased hardness from chilling brass and bronze being small.

The author next discusses the mechanism of hardening by tin and of holding lead by means of tin. A number of other metals and some metalloids are also capable of holding the lead in the alloy. In every case the underlying principle is the same, i.e., the formation of a matrix of hard cells which solidifies at a much higher temperature than lead and which holds this metal until it, in turn, becomes solid. The author shows in an illustration a typical permanent mold such as is used to cast flanged crown bearings for locomotives and gives a method of calculating the thickness of the mold walls. The thickness of the mold walls is in direct proportion to the mass or weight of the crown bearing that is to be cast, and it is determined from the following empirical formula arrived at from practical experiments:

$$\frac{W(t - t')}{Pr \times Rt} \frac{1}{H} = T$$

In which T is the wall thickness in inches; W the weight of the bearing in pounds; t, the pouring temperature of the alloy of which the bearing is made; t' the temperature of the bearing when it is shaken out; Pr the time in minutes during which the bearing is to remain in the mold before it reaches the shaking-out temperature; Rt the maximum allowable increase in temperature of the mold after pouring; and H the height or length of the bearing.

It is easily seen from this formula that with a given casting weight, the thicker the walls of the mold, the shorter will be the period during which the casting must stay in the mold before it is shaken out, and the cooler the mold will be after the casting has been shaken out. This means greater production speed in so far as molding is concerned and a longer life for the mold.

In connection with the molding practice the author calls attention to certain improper methods of using phosphor copper and indicates the correct pouring methods. The saving in tin in using permanent molds is not greater than 10 to 15 per cent of the usual amount required for a sand-cast iron.

With reference to direct costs of production it is safe to say that the saving between the two processes is from 10 to 20 cents per 100 lb. of castings produced in favor of the permanent molds; this in the case where the latest sand-handling and molding machinery is used. This saving may reach 50 cents per 100 lb. of castings produced where permanent molds replace sand molding which is mostly done by hand labor. (Henri Marious, Lenoir Car Works, Lenoir City, Tenn., in *The Metal Industry* (New York), vol. 28, no. 5, May, 1930, pp. 216–220, 7 figs., *d*)

HYDRAULIC ENGINEERING

Hydraulics in Design

THE author describes what he calls the new hydraulics which he defines to include those developments in the hydraulic art which recently have overcome the faults leading to the decreased use of hydraulic tools which took place about 1880. The dominant elements of the new hydraulics are variable-displacement multiple-plunger pumps and units to which he refers as volumetric pumps and motors.

The author divides the various kinds of machinery applied in modern hydraulics into nine basic systems, listed on page 790. The article, which cannot be abstracted because of lack of space, illustrates and describes the nine classes shown on this chart and constitutes a most interesting treatment of the subject. (John P. Ferris, first section of a two-part article in *Machine Design*, vol. 2, no. 3, March, 1930, pp. 27–34, 9 figs., *dA*)

INTERNAL-COMBUSTION ENGINEERING

The Diesel Engine as Applied to Road Transport

A GENERAL description of the main features involved in the application of the Diesel engine to land transport. Among other things the author gives the following interesting comparison between Diesel and gasoline engines.

COMPARISON OF DIESEL AND GASOLINE ENGINES

DIESEL ENGINE	GASOLINE ENGINE
Thermal Efficiency	
35 to 36 per cent. Will run satisfactorily on a very wide range of heavy residual oils; Diesel, fuel, gas oil, tar oils, etc., all of high flash point and today at about one-third cost of gasoline.	22 to 33 per cent. Will only run on gasoline, and the quality of this must not vary greatly. Gasoline is of low flash point and highly dangerous to store and handle.
Fuel Supply	
Fuel supplied to engine by positively driven mechanical pump at exact moment of maximum compression and charge is ignited by heat of compression. No fuel can be wasted. Efficiency at fractional loads.	Mixture of air and gasoline drawn in through carburetor in unsatisfactory manner. Fuel wasted, especially at fractional loads. Fired by spark from magneto.
Compression	
Compression ratio can be safely taken to 16:1 or even higher. Only limited by heat and stresses. Thermal efficiency depends directly on heat of compression.	Compression strictly limited to maximum of 8:1. Usual limit 6:1, owing to self-ignition of mixture.
Distribution of Mixture	
In multi-cylinder engines exact and equal distribution of fuel charge.	Unequal distribution of mixture is unavoidable.
Average Torque	
Period of burning and expansion produces power stroke of considerable duration, resulting in high average torque at all speeds.	Average torque effort poor owing to violent explosive nature of charge.
Starting	
Starting even in coldest weather can be effected in one minute or less. No delay waiting for engine to warm up. Load can be pulled as soon as started.	Difficulty in starting in cold weather. Time needed for warming up before load can be taken.
Danger of Fire	
Entire freedom from danger of fire both on vehicle and in storage, and in haulage of bulk fuel.	Danger of fire at all times both on vehicle and in storage, also in haulage of fuel.
Combustion	
Very perfect combustion, resulting in high thermal efficiency and entire freedom from sump dilution, also no interference with cylinder lubrication. Reduction to practically nil of carbon monoxide gas in exhaust gases.	Imperfect combustion. Always a surplus of fuel resulting in sump dilution, poor cylinder lubrication, formation of hard carbon, and poor thermal efficiency. Dangerous amount of carbon monoxide in exhaust gases.

CHARACTERISTICS OF THE NINE BASIC SYSTEMS OF HYDRAULIC POWER TRANSMISSION

See Fig.	Systems	Typical Embodiment	Degree of Positiveness	Smoothness	Pressure in Line	Efficiency and Heating	Durability	Speed of Motor
1.	Continuous constant displacement volumetric pump and motor.	Plunger pump; 1 to 3 plungers; Hydraulic press. Reversing valve.	Positive motor speed, irrespective of load.	Pulsating motion of motor.	Proportional to load on motor.	Good efficiency at all loads. Little heating.	High durability—no "Wire drawing".	Limited by volume delivered by pump.
2.	Non-continuous constant displacement volumetric pump and motor.	Single stroke impeller pump. Single acting cyl. (no valves) hydraulic brakes.	Positive motor speed, irrespective of load.	Motor motion proportional to motion of impeller.	Proportional to load on motor.	Good efficiency at all loads. Little heating.	High durability—no "Wire drawing".	Limited by volume delivered by pump.
3.	Pump (any kind) Accumulator Throttle Constant displacement motor.	Plunger pump, 1 to 3 plungers (slow). Accumulator. Throttling valve. Hydraulic press.	Motor speed fluctuates according to load and setting of throttling valve.	Motor motion smooth if load does not fluctuate; on fluctuating load it responds to any changes in load.	Remains at maximum value ever required by work.	Low efficiency except when motor is under full load. Heating due to "Wire drawing" at throttle valve.	Subject to erosion at throttling valve seats.	Surplus of fluid stored in accumulator allows momentary motor speeds, under full load, far beyond pump capacity.
4.	Pump (any kind) Accumulator Variable displacement motor.	Plunger pump; 1 to 3 plungers (slow). Accumulator Rotary hydraulic motor, 3 pistons, Variable stroke.	Motor speed fluctuates according to load and setting of motor displacement.	Motor motions smooth if load does not fluctuate; on fluctuating load it responds to any changes in load.	Remains at maximum value ever required by work.	Good efficiency at all loads in excess of about 1/3 maximum load.	High durability—no "Wire drawing"	Adjustable motor displacement allows high speeds at lowloads. Surplus fluid in accumulator allows momentary high motor speeds under full load.
5.	Variable displacement volumetric pump and constant displacement motor.	Variable stroke, multiple plunger pump (high speed). Hydraulic press.	Positive motor speed, irrespective of load.	Smooth motion of motor, irrespective of fluctuations in load.	Proportional to load on motor.	Good efficiency at all loads. Little heating.	High durability—no "Wire drawing".	Limited by volume delivered by pump.
6.	Variable displacement volumetric pump and variable displacement volumetric motor.	Variable stroke, multiple plunger pump (high speed). Variable stroke, multiple plunger motor.	Positive motor speed, irrespective of load.	Smooth motion of motor, irrespective of fluctuations in load.	Proportional to load on motor and inversely proportional to stroke setting of motor	Good efficiency at all loads. Little heating.	High durability—no "Wire drawing"	Adjustable motor displacement allows high motor speeds at low loads. Motor speed limited by volume delivered.
7.	Constant displacement volumetric pump. Relief valve. Throttle valve. Motor.	Gear pump. Relief valve. Throttle valve. Cylinder.	Positive only when throttle is fully open, giving full speed. At reduced speeds, motor speed fluctuates according to load and setting of throttle.	Motor motion smooth at full motor speed under all conditions. At reduced speeds, motor motion responds to any changes in load.	Proportional to load on motor only when throttle is fully open, giving full speed. At reduced speeds remains at maximum value ever required by work.	Good efficiency when throttle is fully open; at reduced speeds efficiency is low and heating occurs.	Subject to erosion at throttling valve when operating at reduced speeds.	Limited by volume delivered by pump.
8.	Turbine pump. Throttle valve. Motor.	Centrifugal pump. Throttle valve. Cylinder.	Motor speed fluctuates according to load and setting of throttle valve.	Motor motion smooth if load does not fluctuate; on fluctuating load it responds to any changes in load.	Remains approximately constant at maximum value ever required by work.	Good efficiency when throttle is fully open. At reduced speeds efficiency is low and heating occurs.	Subject to erosion at throttling valve when operating at reduced speeds.	Limited by volume delivered by pump.
9.	Alternating impulse pump and motor.	Single plunger impeller pump. Expansion chamber.	Positive within each impulse.	Oscillating motion.	Proportional to load plus forces accelerating fluid.	Should give high efficiency.	Presumably good.	Must run at same speed as pump.

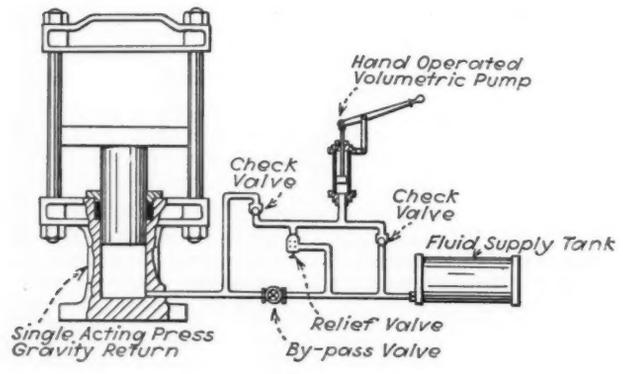

FIG. 1

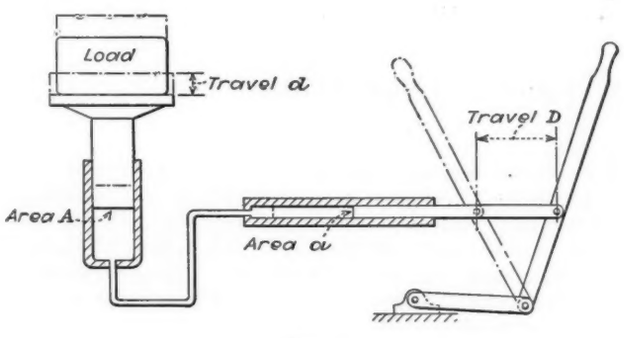

FIG. 2

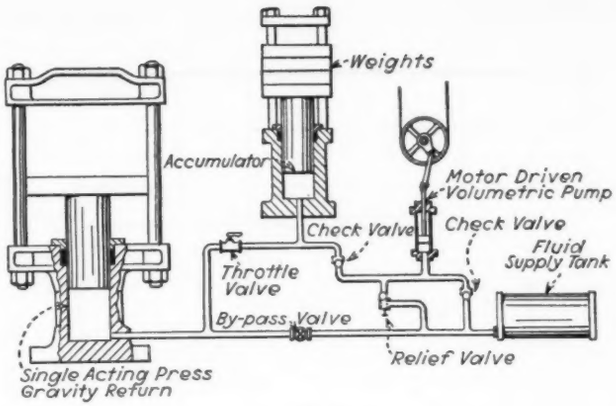

FIG. 3

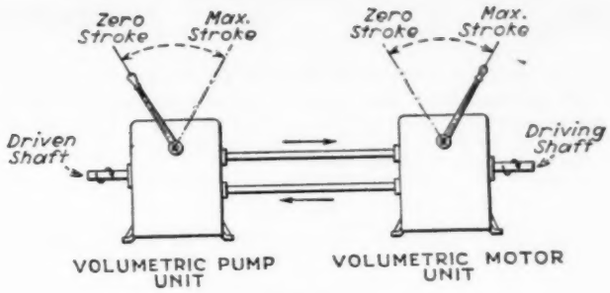

FIG. 6

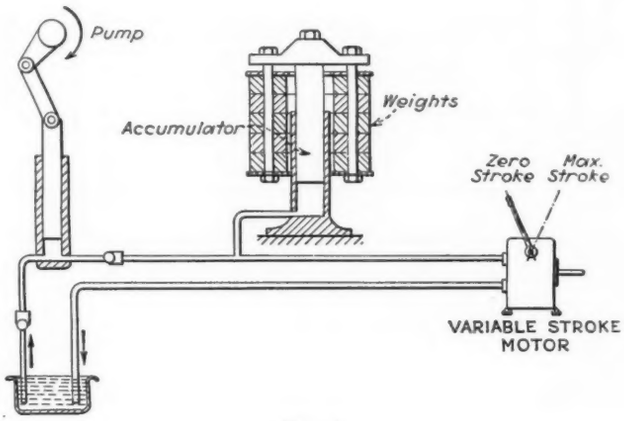

FIG. 4

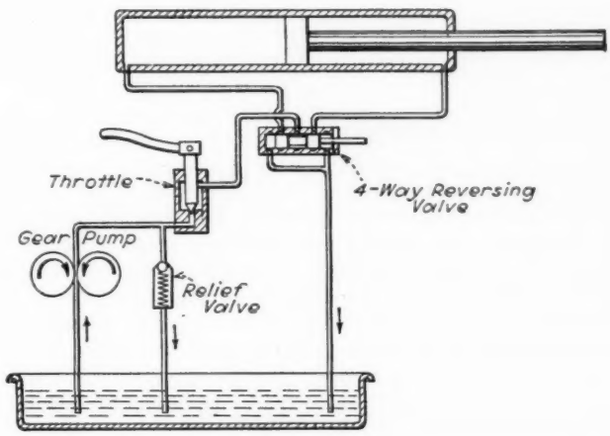

FIG. 7

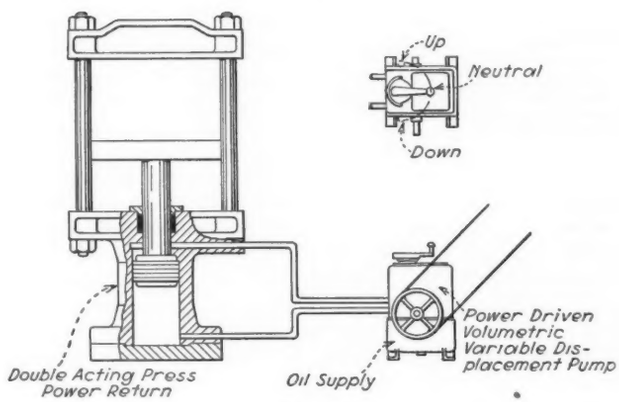

FIG. 5

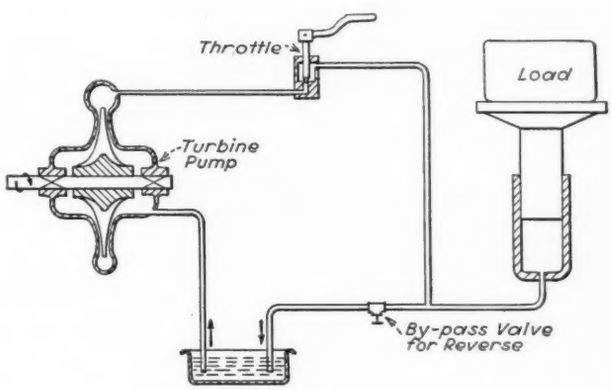

FIG. 8

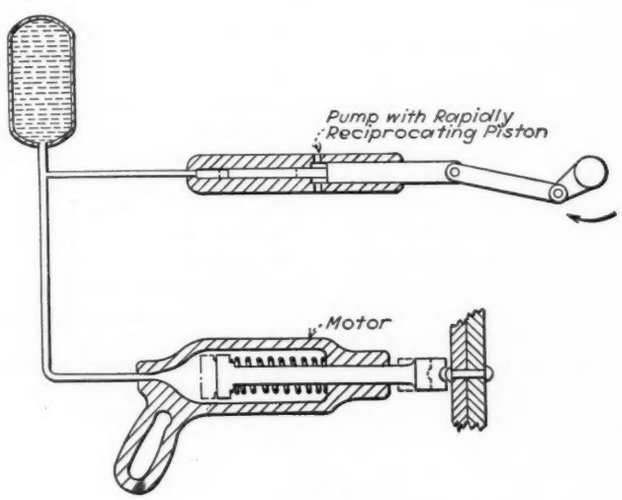

FIG. 9

Specific Gravity

10 to 15 per cent more miles per gallon of fuel owing to heavy nature of the fuels used. Specific gravity approximately 0.870 to 0.880.

Specific gravity of gasoline approximately 0.730, i.e., $1\frac{1}{2}$ lb. less per gallon.

Heat Loss

Heat loss in radiating water 37 per cent.

Heat loss in radiating water 50 per cent.

General Efficiency

High average torque results in better top-gear performance, and therefore higher average speed.

Low average torque results in more gear changing than is required with the Diesel.

(W. H. Goddard in *World Power*, vol. 13, no. 77, May, 1930, pp. 439–444, 8 figs., *d*)

MACHINE PARTS

Anti-Friction Ball and Socket Pillow Block

THESE pillow blocks are known as Link-Belt Timken, and because they use pressure lubrication they are practically dust tight. The grease is forced in at the center and out at the shaft openings. It is claimed that because of this and the addition of the grease sill at the top dust and grit are kept out of the bearing while the grease stays inside the bearing. The construction of the device is shown in Fig. 3. (Link-Belt Company News Items, June 5, 1930, 3 figs., *d*)

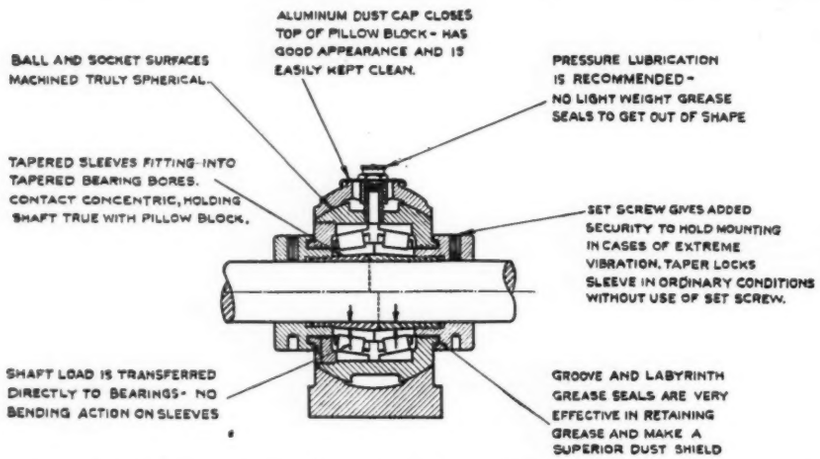
ALUMINUM DUST CAP CLOSES TOP OF PILLOW BLOCK - HAS GOOD APPEARANCE AND IS EASILY KEPT CLEAN.
BALL AND SOCKET SURFACES MACHINED TRULY SPHERICAL.
PRESSURE LUBRICATION IS RECOMMENDED - NO LIGHT WEIGHT GREASE SEALS TO GET OUT OF SHAPE
TAPERED SLEEVES FITTING INTO TAPERED BEARING BORES. CONTACT CONCENTRIC, HOLDING SHAFT TRUE WITH PILLOW BLOCK.
SET SCREW GIVES ADDED SECURITY TO HOLD MOUNTING IN CASES OF EXTREME VIBRATION. TAPER LOCKS SLEEVE IN ORDINARY CONDITIONS WITHOUT USE OF SET SCREW.
SHAFT LOAD IS TRANSFERRED DIRECTLY TO BEARINGS - NO BENDING ACTION ON SLEEVES
GROOVE AND LABYRINTH GREASE SEALS ARE VERY EFFECTIVE IN RETAINING GREASE AND MAKE A SUPERIOR DUST SHIELD

FIG. 10 CROSS-SECTION OF THE LINK-BELT TIMKEN BALL AND SOCKET PILLOW BLOCK

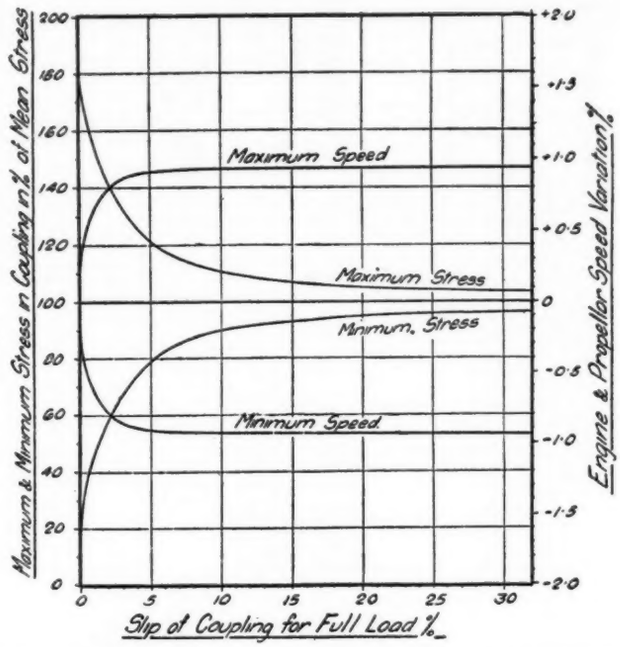

FIG. 11 SPEED AND SLIP CURVES OF FLEXIBLE TYPE OF COUPLING

MARINE ENGINEERING

New Developments in the Application of Electric Machinery to Ship Propulsion

THE most recent development in the use of electrical machinery for ship propulsion is in the coupling together of two different prime movers. This was done in the past by the use of multiple propellers, as, for example, in a triple-screw vessel built by Harland & Wolff with reciprocating steam engines on the wing propellers and an exhaust-steam turbine on the center screw. Another example is the recent triple-screw German cruiser with geared steam turbines on the wing propellers and a Diesel engine on the center propeller. A more important application of dual drive is, however, the coupling together on to a single propeller shaft of two prime movers, each operating under the conditions to which it is ideally adapted. An example of this is the combination of reciprocating engine and exhaust-steam turbine through an electrical generator and motor or through mechanical gearing. The original article shows curves giving turning moments for various types of prime movers and characteristic slow-speed variations, as well as the effect of the cyclic irregularity of the engine torque on a rigid coupling, and the effect of introducing flexibility of the type provided by an electrical coupling consisting of a direct-current generator and motor or by a hydraulic clutch.

The torque transmitted by such a coupling is proportional to the "slip." A fundamental difference between these couplings is that in the former the losses in the coupling are directly proportional to the slip, while in the electrical coupling the slip can be arranged to have any desired value without affecting the losses, and is, moreover, readily adjustable over a wide range. In Fig. 11 the maximum and minimum peak values of a series of curves are plotted against the slip required to transmit full-load torque. The slip should not be much less than 10 per cent if the full advantage of the coupling is to be obtained. With this slip the range of stress is from 90 to 110 per cent instead of from 22 to 178 per cent with the rigid coupling.

The stabilizing effect on propeller speed in rough weather which is exerted by an exhaust turbine coupled to a reciprocating engine by means of couplings with various degrees of slip is also considered. A rigid coupling is examined first.

The different nature of the total stress variation is illustrated by Fig. 12 for couplings having slips of $2\frac{1}{2}$ and 10 per cent.

It will be seen from Fig. 12 that a comparatively small increase in the fluctuation will cause the direction of loading in the stiffer coupling to reverse during part of the cycle, while the electrical coupling has a much greater margin. The electrical coupling under discussion has, however, the valuable property that, in addition to being inherently reversible, it can be designed to have a different slip for forward and for reverse loading.

The effect of the addition of an exhaust-steam turbine to a

quadruple-expansion engine on the stresses in the shafting transmitting 4400 i.hp. at 80 r.p.m. between the motor and the propeller is shown in Fig. 13. The power, speed, and mean stress are

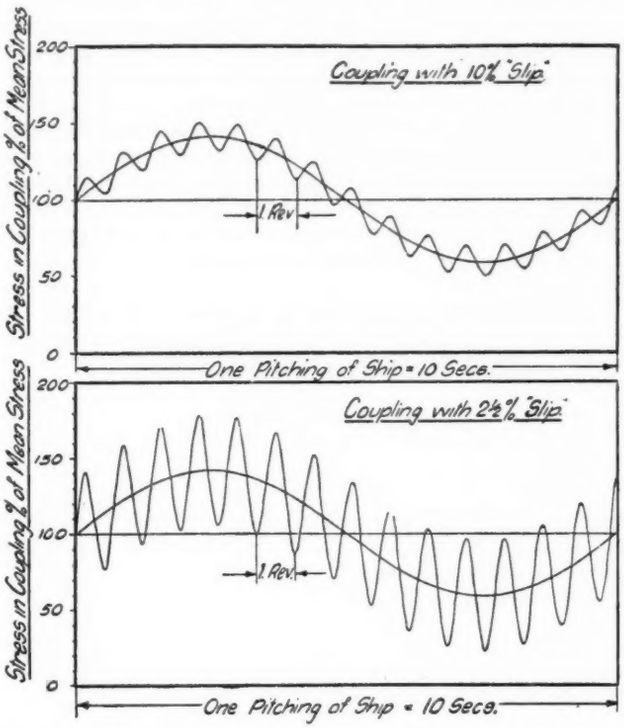

FIG. 12 STRESS VARIATION IN COUPLINGS HAVING SLIPS OF 2½ AND 10 PER CENT

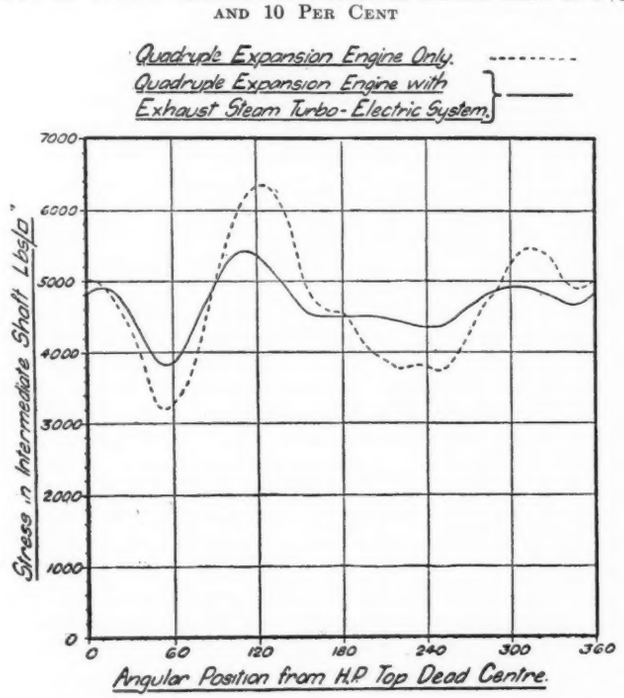

FIG. 13 STRESSES IN SHAFTING BETWEEN MOTOR AND PROPELLER AS AFFECTED BY ADDITION OF AN EXHAUST-STEAM TURBINE TO A QUADRUPLE-EXPANSION ENGINE

the same in each case, but the maximum stress has been reduced from 6350 lb. per sq. in. to 5410 lb. per sq. in. and the range of stress variation from 3150 lb. per sq. in. to 1590 lb. per sq. in. It will be apparent that the power transmitted through the shafting may be very materially increased without enroaching upon the original factor of safety, which depends more upon the fluctuation than on the steady stress.

The author considers also a combination where the electric drive is merely auxiliary. This interesting part of the article cannot be abstracted because of lack of space. The author describes also an installation of a single-screw vessel with geared steam turbines and Diesel-electric machinery. (E. M. Johnson and G. W. Higgs-Walker, paper before the Liverpool Engineering Society, February, 1930, abstracted through *The Shipbuilder*, vol. 37, no. 238, April, 1930, pp. 456–460, 11 figs., *dg*)

Electric Ship Propulsion

IN THE Ellerman liner *City of Hongkong* is employed a combination of a turbo-generator set coupled electrically to a direct-current motor and driven by exhaust steam from a reciprocating steam-engine set. The *City of Hongkong* is a vessel of twelve knots with a displacement of 18,480 tons. It is fitted with a quadruple-expansion reciprocating steam engine developing 4400 i.hp. at 80 r.p.m. The auxiliary turbo-electric equipment has been installed to increase the power and at the same time to reduce the fuel consumption. The trial data show that a very handsome improvement has resulted.

Analysis of the conditions has shown that direct-current electrical machinery forms a good way to couple the reciprocating engine with an exhaust-steam turbine, as the slip can be altered at will and adjusted to the variations of speed of the two prime movers so as to keep the load on the coupling within permissible limits. It is perfectly flexible, thus avoiding shocks on the system due to sudden load changes, and it has no feature corresponding to fatigue in mechanical couplings; in addition, it has an exceedingly high momentary overload capacity and is reversible.

The main and auxiliary generators are driven through single-reduction double-helical gearing to which they are joined by Wellman Bibby coupling. The electric motor, which is rated at 1300 hp. at 83 r.p.m., is built into the line of the propeller shafting and is located well aft in the vessel.

It will be evident that the use of such a coupling enables the steadying effect of the turbine on the reciprocating engine to be exploited to the fullest advantage. The turbine speed can be maintained at its full value over a wide range of engine speeds, so that the flywheel effect is always a maximum and the full capacity of the electrical machinery available to reduce propeller racing to a negligible amount. Not only may a higher propeller speed be maintained in consequence in a seaway, but also, due to the steadier speed of the propeller, appreciably higher propulsive efficiency is obtained than would otherwise be the case, and, of course, the turbine efficiency is improved as well. These two facts have an important bearing on the annual fuel consumption. Loss of speed due to propeller racing and low efficiency must be compensated for by disproportionately increased power at a later part of the voyage, which leads to a high average fuel consumption. If that delay is saved, the fuel consumption will be reduced to normal, and the worse the weather the more important it is to be able to draw upon the steadying effect of the exhaust-turbine equipment.

A further important characteristic of the electrical coupling is its reversibility; the turbine remains in commission and runs in the one direction for either ahead or astern rotation of the propeller. To the advantage of increased astern power in an emergency must be added the elimination of the risk of failure of the disengaging mechanism required with a non-reversible coupling. On a similar installation, which is now in progress of construction for another vessel of the Ellerman Company, a direct steam

connection to the turbine is also to be fitted, so that in the admittedly unlikely, but possible, event of a total breakdown of the reciprocator the turbine will be available for delivering power both ahead and astern. The power available from the turbine alone would enable a speed of 6 to 7 knots to be maintained at least.

The trial data show that the steam consumption per equivalent i.hp-hr. was 23 per cent less with the exhaust turbo-electric system in service than with the reciprocating engine alone. Further tests have shown good endurance and reversing ability. When the vessel was taken into rough weather off the Irish coast she was steaming under light draft and the propeller was partly out of the water. The load on the electrical machinery varied from 20 to 100 per cent of full load. Full propeller revolutions were maintained, and propeller-speed fluctuation was barely noticeable. The variation of load observed indicated the extent to which the steadying effect of the turbine was being used and there was a large reserve of power for dealing with worse conditions. The apparatus handles well at reduced speed and shows good reliability. (*The Electrical Review*, vol. 106, no. 2735, April 25, 1930, pp. 773–777, 9 figs., *d*)

METALLURGY (See also Engineering Materials: Chemical Specifications of Steel)

Making Wrought Iron Mechanically in 700-Lb. Molds

THIS article describes the present practice of The Wrought Iron Company of America, at Lebanon, Pa. The pig iron is melted in an oil-fired air furnace whence it is taken in 700-lb. instalments by ladle and poured into the rotary furnace at a temperature just high enough so that it can be poured without skull in the ladle.

The operations within the rotary furnace where the wrought iron is produced are similar in their general character to those involved in hand puddling, and keep the charge in continuous agitation. Each heat in the rotary furnace requires approximately 45 min. At the end of this time the ball is ready for further processing.

This further processing consists in squeezing the ball in the hydraulic press, where first the form of the bloom is made horizontally to establish its length and width and next the upper ram of the press descends and crushes the mass vertically into the final bloom form. From the hydraulic press the bloom goes to the muck-bar rolls, which are the usual three-high with two sets of rolls side by side. (*Iron Age*, vol. 125, no. 25, June 19, 1930, pp. 1814–1817, illustrated, *d*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering: The Diesel Engine as Applied to Road Transport)

ORDNANCE

The Carden Loyd Baby Tank

THIS tank (also described as a "tankette") was first exhibited in Kensington about September, 1925. In its present form it is a two-man machine with a track composed of 120 drop-forged steel links of one-piece construction keyed together in some such fashion as indicated in Fig. 14. This is important, as during the development period the greatest trouble was given by the track. The two projecting lugs act as retaining guides over the sprockets and idlers, preventing the track from being thrown off at high speeds. This track had a life of some 1000 miles. The present suspension scheme consists of four rollers mounted in pairs so that each pair is free to rock on a connecting flat-leaf spring. The pressure on the track is kept constant and the suspension and track are working out satisfactorily. The tracks are equipped with fenders and mud guards, which are essential in a fast track-laying vehicle.

The wheel-cum-track principle is used, the two large wheels on the side and a smaller wheel in the rear. The shift from wheels to tracks is effected from the outside. The steering is by controlling the drive to either track by brake drums.

In addition to the fighting vehicle there is also a tractor form which is used as a machine-gun carrier and also as a tractor for hauling the caliber 0.8 anti-tank machine gun or a caliber 3.7 cavalry-accompanying howitzer. It can also be used in connection with the 3-in. mortar intended for use as an infantry-accompanying weapon throwing both high-explosive and smoke shells.

The center of gravity is so low and the articulation said to be so

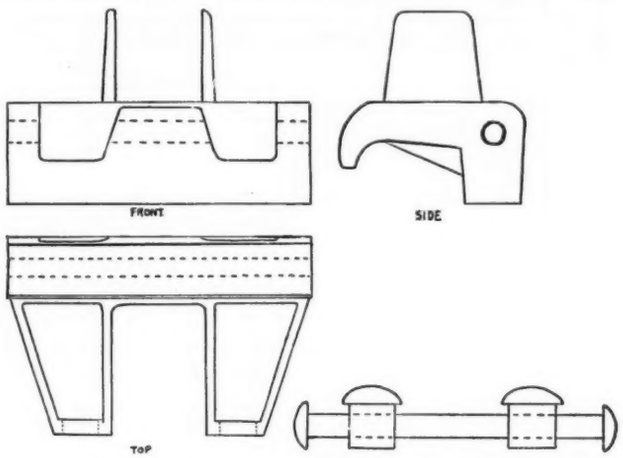

FIG. 14 SKETCH OF CARDEN LOYD TANKETTE TRACK-LINK ASSEMBLY

good that tipping is practically impossible. In speed, it will accomplish between 25 and 30 miles per hour and is mechanically reliable in spite of that speed. It weighs 2500 lb. and is 8 ft. 1 in. long, 5 ft. 7 in. wide, and 3 ft. 4 in. high, has a gasoline capacity of $6\frac{1}{2}$ gal., and will average 8 miles to the gallon. It will cross a vertical obstacle of 2 ft. and ford water up to 1 ft. 6 in. Because of its size and weight it is naturally a somewhat unstable gun mount, but less so than would be expected.

There is every reason to believe that it is the forerunner of a very good, truly light tank. The Imperial General staff laid down specifications based upon the experience gained from the Carden Loyd, and the first model appeared in 1929 designed from those specifications. While little is known of this new model, it is understood to have a single turret and a closed top and will cross a ditch 4 ft. wide. The older models will cross a space about $2\frac{1}{2}$ ft. in width, and it may be assumed from this that the track contains one more set of rollers on either side. This tank is being redesigned and others of the new type will be built in the near future.

While the Carden Loyd is not the last word in light tanks, there is no question but that it is very successful and versatile. A baby tank, but grown up in its achievements and potentialities, it is a most interesting vehicle.

For supplementary information regarding the Carden Loyd machines, readers are referred to the article "Mechanization in Europe," Part II by C. C. Benson, published in the November-December, 1929, issue of *Army Ordnance*. (Robert J. Icks, Lt., Infantry (Tanks) Reserve, U.S.A., Stevens Point, Wis., in *Army Ordnance*, vol. 10, no. 59, March-April, 1930, pp. 321–323 7 figs., *d*)

PETROLEUM ENGINEERING

Oil-Field Operation in Peru

CONTRARY to what happened in Colombia the rotary did not prove a success on the properties of the International Petroleum Company. It was tried in wildcatting and testing out deep sands, but the results were generally unsatisfactory and the process was abandoned. The failure of this process and the preference for cable tools is, of course, due to local conditions only. The recent condition of over-production in the industry has led to the introduction of various economies, such as cutting down of wire-line consumption, casing left in wells, and the adoption of the eight-hour day, with a corresponding reduction in the number of strings of tools operated. The outstanding achievement in the production department has been the successful culmination of their efforts to produce oil on a gas-tight basis. From the time it leaves a completed well until it reaches storage at the refinery no oil is exposed to the atmosphere and no gas or vapors are wasted.

In 1928 gas-lift accounted for 13.7 per cent of the total oil produced; in 1929 this figure increased to 29.3 per cent.

The use of tapered tubing is increasing and general efficiency in operation shows marked improvement.

Over 4,000,000,000 cu. ft. of gas were returned to formation at an average pressure of 225 lb. in repressuring operations that are now general throughout the field. The closest watch is kept on all operations of this nature, and actual visible results are most encouraging.

The field is operated on a unit basis as it belongs entirely to the International Petroleum Company. (*Oil Field Engineering*, vol. 7, no. 6, June, 1930, p. 37, 2 figs., *d*)

Unitization in Colombia

FROM the commencement of operations it has been possible to develop the De Mares Concession in central Colombia in a manner most ideally suited to economic operation. The Concession is operated by the Tropical Oil Company and consists of two major structures known as the Infantas and LaCira anticlines.

In the early stages of development cable tools were used entirely, but later on the rotary was introduced and gradually superseded the cable tools until now the older method is no longer in use. On account of the comparatively soft formation most of the drilling can be done with ordinary fish-tail bits.

It is noteworthy to record that no time is ever lost in the drilling department due to cementing jobs, rigging up, or the usual delays found in a producing field; 20 to 25 rigs are always kept in readiness ahead of time and a rigging-up crew invariably has one or more locations ready for any drilling crew that has finished a job.

As soon as any well is completed a gas-oil ratio test is taken, and throughout the field this feature is always very carefully watched. In cases where a well has an exceptionally high gas-oil ratio, various methods have been tried to reduce this figure. It has been found, however, in this territory that the relative rates of production of gas and oil can only be controlled by some form of back pressure maintained on the face of the sand. The method of production employed will only effect the recovery of oil and gas in so far as it changes this degree of back pressure. On both structures it has been found that the most practicable and effective means of applying back pressure on flowing wells is obtained with the use of "beans."

In 1927 the gas-lift method was first applied, wells on the lower contours that had ceased flowing, although capable of producing several hundred barrels a day, being selected as a rule. By the end of 1929 there were three main gas gathering and distributing plants in the field, two on the Infantas anticline and one on the LaCira. Each plant has compressor equipment capable of taking care of the extraction of petroleum condensate, gas-lift, and repressuring work in its district. At the present time 15,000,000 cu. ft. of gas are utilized daily for gas-lift and repressuring. Gas-lift has been a success since its inception, the handling of the wells, irrespective of the zone, presenting few difficulties.

Repressuring work has been carried on since 1927, but owing to the thickness of the formation and the relatively high formation pressure still remaining, little tangible success has been met with so far. Experimental work of this nature is continuing.

A dehydrating plant to take care of emulsified oil has been in operation since the beginning of 1929. The plant is a converted crude stabilizing plant consisting of four towers 48 in. by 39 ft. and a heat exchanger, two boilers and the necessary pumps and tanks. About 5000 bbl. of emulsion a day is treated with a recovery cost of about 1.4 cents per barrel. (Extract from a report by H. W. Palkowsky in *Oil Field Engineering*, vol. 7, no. 6, June, 1930, pp. 19–21, *d*)

POWER-PLANT ENGINEERING

High Steam-Turbine Efficiencies

THIS paper deals with the Barton power station at Manchester, England. It comprises a 40,000-kw. (M.C.R.) set running in conjunction with three 130,000-lb. Babcock & Wilcox boilers, two of them fired by chain-grate stokers and the third by pulverized coal. The pulverized-coal arrangement was first of the bin and feeder type, but has now been changed to the unit system of direct firing. The overall station efficiency over a period of six months is 23.79 per cent, while the test thermal efficiency of the turbo-alternator has been found to be 32.03 per cent.

The test efficiency of 32.03 per cent was obtained on a 96-min. test at a nominal load of 80 per cent M.C.R., the steam pressure at the stop valve being 372.4 lb. per sq. in. (gage) and temperature 691.7 deg. fahr.; the vacuum was 1.047 in Hg, absolute, corrected to 32 deg. fahr., and the alternator efficiency was 96.87 per cent. After passing the heaters the condensate left for the boilers at 311 deg. fahr. The average load was 35,600 kw. and the net steam consumption was 9.836 lb. per kw-hr. On this basis the total heat supplied was 1364 B.t.u. per lb. of steam, the total heat returned to the boiler house was 281 B.t.u. per lb., and hence the net heat supplied amounted to 1083 B.t.u. Accordingly the total heat consumed was 10,652.7 B.t.u. per kw-hr., which gives the test efficiency of 32.03 per cent. The ratio between the turbine efficiency and the Carnot-cycle efficiency works out at 84.84 per cent, using the 1929 American Society of Mechanical Engineers' heat-drop tables. A further test under summer conditions, with a condenser pressure of 1.659 in. Hg., absolute, gave a thermal efficiency for the set of 31.27 per cent.

Snap tests are valuable up to a point, but the real criterion is performance over a long period. In this case the mean efficiency of Barton B turbine room for six months is given as 30.48 per cent, a very close approximation to the snap-test figure. For the whole Barton B plant the mean overall efficiency is 23.79 per cent, as previously stated. For purposes of comparison, also, the following conditions are worth noting: Load factor, 66.92 per cent; mean gross calorific value of fuel, 11,500 B.t.u. per lb., and ash content, 14.7 per cent. After the usual deductions for banking and raising steam, the boiler-house efficiency is given as 80.62 per cent over six months.

Authoritative figures such as these serve as very useful milestones to mark progress toward perfection. With a ratio of 85 per cent between actual and maximum possible efficiencies there is obviously not a great deal further that can be effected so long as the conventional heat cycle is employed. No more effective

cycle is in sight if we except binary-fluid systems and the pass-out or back-pressure cycles. The latter can, of course, give far higher overall thermal efficiencies if we take into account the heat utilized for other than power purposes. Binary systems may be developed to give somewhat higher efficiencies than those now achieved on the simple Carnot cycle, but on the latter only a relatively small further advance is possible, by way of higher pressures and temperatures. (Paper by H. L. Guy and H. C. Lamb before the Northwestern Branch of the Institution of Mechanical Engineers; abstracted through *The Power Engineer*, vol. 25, no. 290, May, 1930, pp. 200–201, *eA*)

The Effect of Altitude on Power

THERE are four types of power machinery in commercial use today: steam, Diesel and gasoline engines, and electric motors. They are differently affected by altitude.

It makes a difference whether a steam plant is operating condensing or non-condensing as to the effect of altitude.

Mean effective pressure, which is an element in the formula for horsepower, is a function of initial pressure in terms of absolute pressure and of cut-off. For a given initial pressure and cut-off it remains constant, and as it is assumed that the steam conditions remain the same at the higher altitude, the mean forward pressure is constant. On the other hand, mean back pressure, while modified slightly by compression in normal engines, depends almost entirely upon the atmospheric pressure against which the engine is exhausting.

The limiting condition is, of course, that for complete expansion, which is also the case of the properly designed steam turbine. With such a turbine, operating at sea level with atmospheric exhaust and with an initial pressure of 150 lb. gage, the available work per pound of steam will be 136,100 ft-lb., while for the same machine operating at 10,000 ft. altitude, when the back pressure of the atmosphere is about 10.5 lb. per sq. in., there will be available per pound of steam 151,600 ft-lb. of work, a difference of 15,500 ft-lb. per pound of steam, which is 11.4 per cent better than the sea-level condition. In other words, the capacity increases with altitude.

When the engine or turbine is operated condensing, conditions change somewhat. There is an idea that because the vacuum is lower the efficiency must also be lower. Since, however, power and efficiency depend not upon total heats, which are in turn functions of absolute pressure and temperature, the machine is just as efficient at altitudes as at sea level. In this connection it is interesting to note that the change in total heat of the steam in a turbine for instance, from 1 to 2 lb. abs., is about the same as that from 215 to 150 lb. abs. This indicates clearly the enormous importance, not of a high vacuum, irrespective of atmospheric conditions, but of a low absolute pressure in the condenser.

As regards internal-combustion engines, in the gasoline engine altitude reduces the amount of oxygen in the air and hence the amount of fuel that can be burned per unit volume, which in turn reduces the power output of the engine, the indicated mean effective pressure of the engine and consequently the brake mean pressure as well as the brake or overall efficiency. The same conditions obtain in a Diesel engine as in a gasoline engine, but as far as a satisfactory ignition temperature is concerned, the Diesel engine will operate as at sea level.

Electric motors or generators are also effected by high altitudes because the cooling of the machine through removal of heat when the latter is accomplished by air circulation is less at high altitudes than at sea levels, with the result that a motor or generator which at sea level may easily carry its rated load, may or probably will, give considerable trouble at high altitudes due to overheating, unless care is taken to correct the difficulty.

As to remedies there are two essential ones, namely, to carry a machine of a higher rating or to equip the internal-combustion engine with a supercharger, and the author gives figures as to the cost of these remedies for the various types of equipment. (F. H. Dutcher, Dept. of Mechanical Engineering, Columbia University, in *Power*, vol. 71, no. 24, June 17, 1930, pp. 949–951, *cp*)

RAILROAD ENGINEERING

Mechanical Refrigeration With Axle Drive

DESCRIPTION of the Frigicar developed by the North American Car Corporation and using an ammonia compressor driven from the axle of the car by a straight mechanical drive. The drive is taken from one of the truck axles by means of a flexible shaft in combination with sprockets and a roller chain. The universal shaft supported on tapered roller bearings is designed with a special spring arrangement in the sprocket providing two inches of slack for the absorption of switching shocks. The split sprocket on the car axle is clamped in place without special machinging of the axle, an important advantage in case wheel changes become necessary because of flat spots or other causes. Details of the construction of the drive are not yet available.

The car is pre-cooled at the shipper's terminal by driving the compressor with a 5-hp. induction motor. Three cooling coils are installed in the car—one inside, one at the front, and one at the back of each brine tank. If the compressor could be kept running all of the time no brine tanks would be necessary, but as the train stops frequently and sometimes for long periods, the ammonia compressor is not always in operation. Furthermore the train runs at variable speeds and an excessive amount of refrigeration is produced at certain times while at others not enough is produced. The two brine tanks are used to equalize this irregularity. (*Railway Electrical Engineer*, vol. 21 no. 4, April, 1930, pp. 111–113, 4 figs., *d*)

SPECIAL PROCESSES

Manufacture of Guns by Centrifugal Casting

ACCORDING to Brig.-Gen. T. C. Dickson, Commanding Officer at Watertown Arsenal, Watertown, Mass., large-type guns can be manufactured stronger at less cost and in shorter time by using centrifugal steel castings and the cold-working process than by the built-up method.

Of particular interest is the machine used to cast the guns centrifugally. It consists primarily of a rotor revolved in a horizontal position at high speed, into which the molten metal is poured. The rotor is allowed to gain full speed, after which the pouring is made. Centrifugal force throws the metal to the periphery of the rotor and, as General Dickson states, works the air to the center, as well as segregates the carbon at the bore. After the metal is solidified the rotor is stopped and the casting placed in the soaking pit.

The bore having been reamed out to the desired size, the gun casting is prepared for the cold-working process. Hydraulic pressure is employed to increase the size of the bore, and in so doing raises the elastic limit of the casting. In his paper General Dickson drew comparisons between built-up guns and those processed in the centrifugal casting machine, showing the increased efficiency of the latter. A stronger gun of considerably less weight can be made by the centrifugal method and cold working, he declared.—Paper before the Cleveland Engineering Society, Cleveland, Ohio, May 13, 1930; abstracted through *Iron Trade Review*, vol. 86, no. 22, May 29, 1930, p. 61.

Instruments and Apparatus

Preliminary Draft of Part 3—Temperature Measurement; Chapter 5, Pyrometric Cones

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 3, "Temperature Measurement," Chapter 5, "Pyrometric Cones" of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, G. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, and E. B. Ricketts.

The "Instruments and Apparatus" Section will consist of twenty-two parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (12 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Materials, (6) Electrical Measurements,[4] (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition (5 chapters), (11) Determination of Quality of Steam,[5] (12) Time Measurements, (13) Speed Measurement,[6] (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke, (21) Leakage Measurements (2 chapters),[8] and (22) Hydraulic Power Plants.

Description and Classification

1 The pyrometric cones most frequently used are a set of Orton cones, consisting of a series of tetrahedrons made in various sizes, but usually 0.78 or 2.75 in. (2 or 7 cm.) in height with a 0.29 or 0.59 in. ($^3/_4$ or $1^1/_2$ cm.) triangular base,[9] respectively. The cones are made of varying compositions (mineral and chemical mixtures) such that they will soften and bend in a graded manner when subjected to the proper heating. Each cone bears a number which represents the temperature at which the tip of the cone touches the pat on a level with the base of the cone when the cone is heated under certain standardized conditions. This temperature is called the "end point" of the particular cone. (See Par. 5.)

2 Pyrometric cones are employed either for regulating temperatures such as in kiln practice or for comparison with "test" cones of refractory products such as brick, fireclay, or high-temperature mortar. In the latter use, a test cone is mounted side by side, with a series of pyrometric cones, and when heated until the tip of the test cone touches the pat on a level with the base of the cone, the pyrometric cone equivalent (P.C.E. value) of the test cone is noted by the number of the adjacent pyrometric cone which reached its end point at the same time. The following description and discussion deal with the use of cones for obtaining the end-points or P.C.E. values of materials rather than for regulating temperatures. Certain of the remarks, however, will apply to the use of cones for the latter purpose as well.

3 Cones do not fuse sharply but soften over a temperature range having a beginning and an end-point. The bending intervals for various Orton cones heated at 302 deg. fahr. per hr. vary from 10 to over 100 deg. fahr. The end-point is reached before the cones are fused. Even the end-points are not a property of the cone but depend on the conditions of heating, i.e., the rate of heating and the test furnace atmosphere, and also on the angle at which the cones are mounted.

4 Cones as used in P.C.E. tests of refractory materials are not looked upon as being suitable for indicating actual end-points under service conditions due in part to the uncertainty in the use of the cones themselves, but due more to the fact that the atmospheres and rates of heating in the test and service furnaces are not the same. It is generally assumed that first quality refractory brick can be readily distinguished from second quality brick by their P.C.E. values but that differences in P.C.E. values between two first quality firebricks may not, with exactness, indicate their relative refractoriness under service conditions.

5 In this country Orton pyrometric cones are generally used. Other cones which might be used differ from Orton cones in numbering and also in composition.[10] The following cone-temperature table[11] (Table 1) gives the end-points for standard pyrometric cones as manufactured by Professor Orton.[12]

Advantages and Disadvantages

6 The principal advantages of this method of determining temperatures are the inexpensiveness of the cones and their convenience of application.

The principal disadvantages are:

(*a*) Gases attack some ingredients in the cones, affecting their end-points
(*b*) The rate of heating affects the end-points
(*c*) Cones will not respond to nor indicate the maximum temperature attained
(*d*) They are not applicable for high precision temperature measurement (see Par. 8)
(*e*) The characteristics of the cones are varied and complex

[1] See Mechanical Engineering, February, 1923.

[2] Chapter 1 of Part 2, on "Barometers," was published in the November, 1927, issue of Mechanical Engineering.

Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in the July, 1928, issue of Mechanical Engineering.

[3] Chapter 1 of Part 3, "General," was published in the December, 1925, issue of Mechanical Engineering.

Chapter 6 of Part 3, on "Glass Thermometers," was published in the April and May, 1926, issues of Mechanical Engineering.

Chapter 7 of Part 3, on "Pressure-Gage Thermometers," was published in the October, 1928, issue of Mechanical Engineering.

[4] See Mechanical Engineering, December, 1928.

[5] See Mechanical Engineering, June, 1930.

[6] See Mechanical Engineering, April, 1929.

[7] See Mechanical Engineering, March, 1930.

[8] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in the November, 1925, issue of Mechanical Engineering.

[9] The larger size is used in kiln practice and the smaller size in P.C.E. tests.

[10] See "A Comparison of the Softening Points of Some Foreign and American Pyrometric Cones," *Jour. American Ceramic Society*, vol. 9, no. 11, Nov., 1926, p. 748.

[11] The conditions under which this table is valid must not be overlooked (see footnote 13, Par. 5). The table is included for two reasons, namely, (*a*) for its value in selecting the proper Orton cones to mount with a test cone whose approximate end-point is known in degrees Fahrenheit and (*b*) for its value as a standard for checking a shipment of Orton cones.

[12] Made by Standard Pyrometric Cone Company, Columbus, Ohio.

TABLE 1 END-POINTS[13] OF ORTON CONES

Cone no.	End-point, F	Cone no.	End-point, F	Cone no.	End-point, F
022	1121	02	2057	19	2768
021	1139	01	2093	20	2768
020	1202	1	2120	23[14]	2876
019	1220	2	2129	26	2903
018	1328	3	2138	27	2921
017	1418	4	2174	28	2939
016	1463	5	2201	29	2984
015	1481	6	2246	30	3002
014	1526	7	2282	31	3056
013	1580	8	2300	32	3092
012	1607	9	2345	33	3173
011	1661	10	2381	34	3200
010	1643	11	2417	35	3245
09	1706	12	2435	36	3290
08	1742	13	2462	37	3308
07	1814	14	2552	38	3335
06	1859	15	2615	39[15]	3389
05	1904	16	2669	40	3425
04	1940	17	2687	41	3578
03	2039	18	2714	42	3659

(*f*) Their use requires a pyrometer for controlling the rate of heating of the cones

(*g*) The cone series is not uniform in temperature intervals.

Range and Accuracy

7 The temperature range of pyrometric cones is approximately 1100 to 3650 deg. fahr. in varying progressive steps. For refractory products P.C.E. tests the working range is from about 2500 to 3300 deg. fahr.

8 The accuracy of temperature measurements by this method depends upon the furnace conditions, the rate of heating of the cones, the care with which the cones were manufactured, the mounting and position of the cones, and the personal error involved in judging the end-point. Different laboratories running P.C.E. tests on the same refractory product may differ by as much as one or two cones.

Preparation for Test

9 When end-points of materials such as refractory brick, fireclay, etc., are to be determined, test cones made from the material to be tested must be prepared prior to mounting with Orton standard pyrometric cones. For methods of preparing such test cones see the "Test Code for Solid Fuels," Pars. 48 and 49, and the A.S.T.M. Standard Method of Test for Determining the Pyrometric Cone Equivalent of Fireclay and Firebrick, Serial Designation C24–28.

10 The cones are mounted on pats of refractory material[16] of such composition as will not affect the end-points of the cones. They shall be mounted with the base embedded approximately $1/8$ inch in the pat, and the face of one side inclined at an angle of about 82 deg. with the horizontal. The test cones shall alternate with Orton cones in such a way that Orton cones of successive numbers will be placed opposite each other. If a P.C.E. value of about 32 is expected for the unknown test cones, then the Orton cones selected for mounting on the pat should be of the order of 31, 32, and 33. The pat may be circular, about $2\frac{1}{4}$ inches in diameter and $1/2$ inch thick, or rectangular, and it may be baked to harden it, either previous to mounting the cones or afterward. The cones may be attached to the pat with the same kind of cement from which the pat was made, but the cement should not be heaped around the cones as this will tend to hold the cone upright after it has softened.

11 Recent investigations have shown that the granular carbon resistance furnace yields more definite and exact results than either gas-air or oxyacetylene furnaces. However, the oxyacetylene furnace is valuable for P.C.E. values above Orton cone 35.

Making a Test

12 A standardized procedure should be adopted which is reproducible and controllable for the particular test furnace being used. The nearer the service-furnace atmospheres are obtained in the test furnace the greater will be the value of the test results. End-points obtained in an oxidizing atmosphere may run 100 deg. fahr. or more higher than those obtained in a reducing atmosphere. Such would be the magnitude of the error due to this cause, if the applications of the results so obtained are to be applied to boiler fuel-bed conditions. The rate of heating in the laboratory will not in any case approximate long-continued heating in service.

13 For a standard method of conducting a test employing cones see the A.S.T.M. Standard Method of Test for Determining the Pyrometric Cone Equivalent of Fireclay and Firebrick, Serial Designation C24–28.

Precautions

14 The factors which control the actions of cones during their heat treatment may be divided into two classes, namely, (*a*) those controllable to a large extent by the maker, and (*b*) those controlled to a greater or less degree by the user. The first class includes (1) size and shape, (2) fineness of particles, (3) intimacy of mixture, (4) porosity and homogeneity, (5) chemical and mineralogical composition including impurities, (6) physico-chemical composition of materials and particles including whether they are crystalline, colloidal, amorphous, or glassy, and whether water of crystallization, dissolved or absorbed gases, etc., are present, and (7) unknown factors controlled by fixed methods of making. Those in the second class are: (1) mounting and position (avoid direct impingement of the flame on the cones), (2) oxidation of organic binder, (3) release of H_2O and CO_2, (4) rate of firing, (5) furnace atmosphere, (6) velocity of furnace gases, (7) unknown factors controlled by standardized practice. For details see "Characteristics of Pyrometric Cones," by C. O. Fairchild and M. F. Peters, *Jour. American Ceramic Society*, vol. 9, No. 11, Nov., 1926.

Corrections and Calibration

15 The rate of heating, particularly during the bending interval, has a marked effect upon the end-points. If necessary, the error resulting from improper rate of heating can be established by test and corrections applied to the observed values taken on subsequent tests during which the rate of heating is abnormal, but in every case a test furnace in which the rate of heating can be controlled should be employed if available. If the cones show a visible hardening of the surface or a skin effect resulting from exposure to gases, corrections may be necessary.

16 To check the accuracy of Orton cones, one of each number from each lot received shall be heated in air at a standard rate,[17] comparing its actual end-point, as indicated by a standardized thermocouple, with the value given in the chart of Par. 5. For tolerance of values given in the chart see footnote 13 of Par. 5.

[13] End-points apply only when cones are heated under certain standardized and reproducible conditions. In this case the rate of heating was 302 deg. fahr. per hr. and the cones were heated in air in an electric furnace. For a discussion of the effects of change in rate of heating and the influence of gases on end-point determinations see "Characteristics of Pyrometric Cones," by C. O. Fairchild and M. F. Peters, *Jour. American Ceramic Society*, vol. 9, no. 11, Nov., 1926. The values given are rounded mean values and the maximum difference from mean was about 9 deg. fahr. up to 2550 deg. fahr. and about 18 deg. fahr. from that temperature up to 3630 deg. fahr.

[14] Cones 21, 22, 24, and 25 are not available.

[15] Cones 39, 40, 41, and 42 were heated in an Arsem furnace at a rate of 1112 deg. fahr. per hr.

[16] Ground Alundum and Norton 518 cement mixed together with as little water as possible is suitable.

[17] 302 deg. fahr. per hr. is the standard rate when comparing with the values given in the cone-temperature chart of Par. 5.

Engineering and Industrial Standardization

Safety Rules for Gas Equipment With Special Reference to Welding

THE following extract of the G. E. Safety Rules for Gas Equipment is published with the permission of the General Electric Company. In addition to the portions quoted, rules are included for regulators and hose, with explanation of the various gases, and "Donts'" and precautions for operators.

This manual is published for the purpose of providing welders and others handling gases with information which will increase the safety of men and equipment.

Classification of Gases

For considerations of safety, gases may be divided into four classes: 1 Inert; 2 Explosive or fuel gases; 3 Poisonous; 4 Oxygen, which forms an explosive mixture with other materials.

Equipment

Cylinders. Any cylinder or tank containing a gas under pressure is dangerous and must be handled carefully.

(1) Excessive heat will weaken the metal, perhaps to the point where the pressure of the gas will blow up the cylinder. Heat also causes the gas to expand, increasing the pressure so that while the tank is weakened by the heat, at the same time an added strain is put on the tank because of the increased pressure.

Rule 1. Keep cylinders and tanks at room temperatures.

(2) Hammering a metal weakens it. A cylinder in use for years gets many minor jars and bumps. If it is dropped from a truck or other height the jar may be enough to crack it or start a seam open—causing it to explode.

Rule 2. Handle cylinders carefully.

(3) Oil and oxygen will burn and may explode. Dirty cylinders usually mean greasy cylinders.

Rule 3. Keep cylinders clean.

Cylinder Valves

(*a*) Use only the wrench provided for opening valves.

(*b*) Don't try to show how strong you are when closing valves; close them only snug tight.

(*c*) Most valves contain the fusible plug or bursting disk, which is the safety valve of the cylinder; therefore, don't abuse the valve in any way.

(*d*) If the valve stem leaks, tighten the stuffing box *slightly* with a *small* wrench.

(*e*) Always leave the wrench on the acetylene cylinder so that it can be shut off quickly in case of trouble.

Welding Torches

(*a*) Use the proper size torch and tips for the work at hand. Special equipment is available for special work.

(*b*) Use pressures which are specified on the tables applying to the torch you are using. These tables should be obtained from your foreman.

(*c*) Carry only enough fuel-gas pressure to do the work, and adjust this pressure with the regulator only.

(*d*) Never use a torch which leaks in any part or connection.

(*e*) Don't use a torch that gets hot or flashes back.

(*f*) Use nothing but copper or brass wire to clean out tips. Many tips are damaged or ruined by cleaning with steel wire, drills of wrong size, etc. A scratch in the tip hole will give a ragged and poor welding flame and spoil an expensive tip.

(*g*) Don't use the torch and tip for a crowbar, wedge, hammer, or for any other purpose than welding.

Cutting Torches

(*a*) Use the smallest-size tip and the least gas pressure that will do the work satisfactorily. Follow the tables furnished to determine the best practice. These tables should be obtained from your foreman.

(*b*) A cutting torch has two distinct adjustments—one for the fuel gas and oxygen for the heating flames, which are around the outside of the tip; the other for the pure, clear, oxygen jet in the center. Upon the proper regulation of these and the speed of the cut, largely depends the quality of the work produced.

(*c*) Extra tips when not in use should be carefully put away to avoid damage. Never throw them in drawers or boxes, loose, with other tools.

(*d*) Use only copper or brass wire to clean the tips.

Precautions for Operators

(*a*) When working in a confined space such as a small room or inside a tank, be sure of proper ventilation and do not allow any gas to escape from the unlighted torch or leaks.

(*b*) Never attempt to weld a closed or jacketed tank, vessel, or container until after every possible precaution has been taken to make an adequate vent for the confined air.

(*c*) Never attempt to weld a container which has contained oil, gasoline, or any other combustible liquid or gas until it has been thoroughly cleaned by washing, and then make sure it is adequately ventilated.

(*d*) When welding or cutting in the field make sure that there is no inflammable material connected to the metal being welded. Make sure that there is no explosive gas or dust about. Do not weld or cut where the sparks or hot metal will fall on anything inflammable.

(*e*) Do not cut so that the metal or sparks will fall on you or on the hose.

(*f*) If in doubt about the safety of cutting or welding in any location, consult the welding supervisor, foreman, or fire chief; do not take a chance.

(*g*) Welding on brass or bronze should be done only in well-ventilated places, and if the work is continuous, suitable respirators must be worn.

(*h*) Do not call for a cylinder of gas or air, call them by name, acetylene, hydrogen, oxygen, etc.

(*i*) Do not adjust, alter, change, build, or do any experimental work on gas cylinders, regulators, torches, or any other gas equipment.

(*j*) Use cylinders in an upright position; do not lay them on their side.

(*k*) Cylinders not in use should be stored in a rack, and when in use should be held in a truck or rack.

(*l*) Suitable and approved goggles, gloves, aprons, shoes, helmets, and other protective clothing and equipment shall be used where necessary.

25-Lb. Cast-Iron Pipe Flanges and Flanged Fittings

THIS proposed American Tentative Standard for 25-lb. Cast-Iron Pipe Flanges and Flanged Fittings has been developed by Subcommittee No. 1 of the Sectional Committee on Pipe Flanges and Fittings to cover the low-pressure range of service and, prior to its submission to the American Standards Association for formal approval, it is published here for the criticism and comment.

This standard includes introductory notes covering size, pressure ratings, marking, material, dimensions, facing, bolting, spot facing, reducing fittings, elbows, and screwed companion flanges, together with a graphic explanation of the method of designating outlets of reducing tees, crosses, side-outlet tees, and side-outlet elbows, when ordering, as well as the tabulated standard dimensions. These dimensions are given in four tables covering templates for drilling, dimensions of elbows, dimensions of tees and crosses, and dimensions of reducing fittings, the first two of which are reproduced here as being typical of the standard and showing the range of sizes included. Supplementing these a fifth table indicates the theoretical weights of the various types of fittings in sizes ranging from 4 to 72 in.

25 Lb. Cast Iron Flanged Fittings

Table 1 Templates for Drilling

Size	Diameter of Flange	Minimum Thickness of Flange[3,4]	Diameter of Bolt Circle	Number of Bolts[1]	Diameter of Bolts	Diameter of Bolt Holes	Length of Bolts[4,5]	Total Effective Area Bolt Metal	Stress Lb. per Sq. In. Bolt Metal[5,6]	Size of Ring Gasket
4	9	3/4	7 1/2	8	5/8	3/4	2 1/4	1.616	570	4 × 6 1/8
5	10	3/4	8 1/2	8	5/8	3/4	2 1/4	1.616	750	5 × 7 1/8
6	11	3/4	9 1/2	8	5/8	3/4	2 1/4	1.616	930	6 × 8 1/8
8	13 1/2	7/8	11 3/4	8	5/8	3/4	2 1/4	1.616	1470	8 × 11
10	16	7/8	14 1/4	12	5/8	3/4	2 1/2	2.424	1440	10 × 13 3/8
12	19	1	17	12	3/4	7/8	2 3/4	2.424	2195	12 × 16 1/8
14	21	1 1/8	18 3/4	12	3/4	7/8	3 1/4	3 62	1750	14 × 18
16	23 1/2	1 1/8	21 1/4	16	3/4	7/8	3 1/4	4 83	1710	16 × 20 1/2
18	25	1 1/4	22 3/4	16	3/4	7/8	3 1/2	4 83	1965	18 × 22
20	27 1/2	1 1/4	25	20	3/4	7/8	3 1/2	6 36	1920	20 × 24 1/4
24	32	1 3/8	29 1/2	20	3/4	7/8	3 3/4	6 36	2690	24 × 28 3/4
30	38 3/4	1 1/2	36	28	7/8	1	4 1/4	11 76	2030	30 × 35 1/8
36	46	1 5/8	42 3/4	32	7/8	1	5	13 44	2610	36 × 41 1/2
42	53	1 3/4	49 1/2	36	1	1 1/8	5 1/4	19 80	2315	42 × 48 1/2
48	59 1/2	2	56	44	1	1 1/8	5 1/2	24 20	2475	48 × 55
54	66 1/4	2 1/8	62 3/4	44	1	1 1/8	5 3/4	24 20	3195	54 × 61 3/8
60	73	2 1/4	69 1/4	52	1 1/8	1 1/4	6	36 02	2515	60 × 68 1/8
72	86 1/2	2 1/2	82 1/2	60	1 1/8	1 1/4	6 1/4	41 57	3120	72 × 81 1/2
84	99 3/4	2 3/4	95 1/2	64	1 1/4	1 3/8	7 1/4	57 14	3005	84 × 94 1/2
96	113 1/4	3	108 1/2	68	1 1/4	1 3/8	7 3/4	60 57	3705	96 × 107 1/4

All dimensions given in inches.

[1] NOTE: Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line. Bolt holes are drilled 1/8 inch larger in diameter than the nominal diameter of the bolt.

[2] NOTE: The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 in. and larger may be spot faced or back faced to minimum thickness of flange with a plus tolerance of 1/4 inch, so that standard length bolts can be used.

[3] NOTE: All 25 lb. cast iron standard flanges have plain faces.

[4] NOTE: Screwed Companion Flanges "should not be thinner than the '125 lb. American Standard' thickness on sizes 24 in. and smaller. Other types of flanges may have thicknesses as given in the table above."

[5] NOTE: Bolts shall be of steel with standard "Rough Square Heads" and the hexagon nuts shall be of steel with "U. S. standard dimensions."

[6] NOTE: The stress shown is that of internal pressure only, assumed to act on a circular area equal in diameter to the outside diameter of a ring gasket covering the flange to the inside of bolts.

In 1928 the American Standards Association approved two other standards developed by this same Subcommittee, both covering cast-iron fittings, the one for 125-lb. and the other for 250-lb. service. It is expected that these will be followed shortly by an additional cast-iron standard covering a still higher pressure range and rated at 800 lb. which is now in the hands of the three sponsor bodies for approval prior to submission to the American Standards Association for final approval and designation as an American Standard.

The Sectional Committee on Pipe Flanges and Fittings, under whose direction these standards were formulated, was organized in 1921 with the Manufacturers Standardization Society of the Valve and Fittings Industry, the Heating and Piping Contractors National Association, and The American Society of Mechanical Engineers as joint sponsors, for the purpose of unifying and extending the various flanged-fitting standards, a number of which were in use at that time. The scope of the Committee's activity covers dimensional standardization and designation of materials for pipe flanges and flanged and screwed fittings over the extensive field in which this general class of equipment is used as well as in connection with several special applications. Because of the great diversity of interest represented, subcommittees were appointed, to each of which a particular branch of the subject was designated, and this 25-lb. standard is the fourth to be prepared by Subcommittee No. 1 on Cast-Iron Pipe Flanges and Flanged Fittings.

The Sectional Committee with Dean Collins P. Bliss, chairman, and Albert C. Taylor, secretary, is divided into its several subcommittees as follows: Subcommittee No. 1 on Cast-Iron Flanges and Flanged Fittings, Arthur M. Houser, chairman, which, in addition to having formulated the four standards mentioned above, is engaged in the preparation of a standard for ammonia fittings; Subcommittee No. 2 on Screwed Fittings, Stanley G. Flagg, Jr., chairman, which has developed three standards, i.e., Malleable-Iron Screwed Fittings, Cast-Iron Screwed Fittings, and Cast-Iron Long-Turn Sprinkler Fittings, all of which have been approved by the American Standards Association, and which has also prepared a standard for Screwed Pipe Plugs; Subcommittee No. 3 on Steel Flanges and Flanged Fittings, Collins P. Bliss, chairman, which was responsible for the development of the Tentative American Standard on Steel Pipe Flanges and Flanged Fittings, approved some years ago, and which is now preparing standards on Steel Base Fittings and Steel Companion Flanges; Subcommittee No. 4 on Materials and Stresses, Arthur M. Houser, chairman; Subcom-

25 Lb. Cast Iron Flanged Fittings

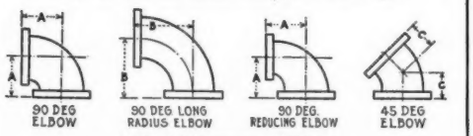

Table 2 Dimensions of Elbows

Nominal Pipe Size[1,2]	Center to Face Elbow[3,5,6] A	Center to Face Long Radius Elbow B	Center to Face 45 Deg. Elbow[3] C	Diameter of Flange	Thickness of Flange[4] (Min.)	Metal Thickness of Body (Min.)
4	6 1/2	9	4	9	3/4	0.42
5	7 1/2	10 1/2	4 1/2	10	3/4	0.44
6	8	11 1/2	5	11	3/4	0.44
8	9	14	5 1/2	13 1/2	7/8	0.46
10	11	16 1/2	6 1/2	16	7/8	0.50
12	12	19	7 1/2	19	1	0.54
14	14	21 1/2	7 1/2	21	1 1/8	0.57
16	15	24	8	23 1/2	1 1/8	0.60
18	16 1/2	26 1/2	8 1/2	25	1 1/4	0.64
20	18	29	9 1/2	27 1/2	1 1/4	0.67
24	22	34	11	32	1 3/8	0.76
30	25	41 1/2	15	38 3/4	1 1/2	0.88
36	28	49	18	46	1 5/8	0.99
42	31	56 1/2	21	53	1 3/4	1.10
48	34	64	24	59 1/2	2	1.26
54	39	71 1/2	27	66 1/4	2 1/4	1.35
60	44	79	30	73	2 1/4	1.39
72	53	94	36	86 1/2	2 1/2	1.62

All dimensions given in inches.

[1] NOTE: Size of all fittings listed indicates nominal inside diameter of port.

[2] NOTE: The flange diameters, bolt circles, and number of bolts are the same as the "125 Lb. American Standard (A.S.A. B16a–1928)" with a reduction in the thickness of flanges and the bolt diameters as shown in Table 2, thereby maintaining interchangeability with the "125 Lb. American Standard" flanges.

[3] NOTE: The center to face dimensions of fittings are the same as the "125 Lb. American Standard" cast iron flanged fittings.

[4] NOTE: "Screwed Companion Flanges" should not be thinner than the "125 Lb. American Standard" thickness on sizes 24 in., and smaller. Other types of flanges may have thicknesses as given in the table above.

[5] NOTE: Special degree elbows, ranging from 1 to 45 degrees inclusive shall have the same center to face dimensions given in 45 degree elbows and those over 45 degrees and up to 90 degrees inclusive shall have the same center to face dimensions as given for 90 degree elbows. The angle designation of an elbow is its deflection from straight line flow and is the angle between the flange faces.

[6] NOTE: Side outlet elbows and side outlet tees shall have all openings on intersecting center lines.

mittee No. 5 on Face-to-Face Dimensions of Ferrous Flanged Valves, F. H. Morehead, temporary chairman; Subcommittee No. 6 on Malleable-Iron or Steel Brass-Seat Unions; Subcommittee No. 7 on Rating of Pipe Fittings, H. C. Heaton, chairman; and Subcommittee No. 8 on Marking of Pipe Fittings, W. S. Morrison, temporary chairman.

A copy of the complete 25-lb. Cast-Iron Standard, reproduced here in part, may be obtained by those who wish to make a more detailed survey of its contents by addressing a request to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 643 (Reopened), 649–651 inclusive, as formulated at the meeting on May 23, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 643 (REOPENED)

Inquiry: Is it the intent of the rules in the Code for dished heads, that the thickness of the plate ordered for forming shall be sufficient to maintain the required thickness at the corner radius of the knuckle where it may thin down between 5 and 10 per cent, or is the factor of safety provided for heads sufficient to take care of this thinning in the case of plain heads as well as manheads?

Reply: It is the opinion of the Committee that the required thickness for dished heads as determined by the formula in the Code is sufficient to provide for thinning down to a maximum of 10 per cent at the corner radius of the knuckle due to the process of forming for both plain heads and manheads.

CASE NO. 649

Inquiry: Is it permissible to attach dished heads to cylindrical shells by the brazing process where the plates for the shells exceed $^3/_8$ in. in thickness? Par. U-91 of the Code limits the brazing process to plates $^3/_8$ in. thick, but this general requirement is intended presumably for longitudinal joints on account of the disadvantage of eccentricity, which does not exist in the case of inserted heads.

Reply: There is nothing in the Code at present to provide for this construction, but a revision to cover this feature is under consideration by the Boiler Code Committee.

CASE NO. 650 (In the hands of the Committee)

CASE NO. 651

Inquiry: Is it necessary, in a miniature boiler made of cast steel and generating steam in a closed system only by means of electric heating elements, to apply the requirements of Par. M-11 if there are available openings for other purposes that can be used occasionally for inspection and cleaning? If the application of Par. M-11 is not necessary for such a generating unit, can it be stamped with the A.S.M.E. Code symbol?

Reply: It is the opinion of the Committee that in a miniature boiler of the closed-system type which is heated by removable internal electric heating elments and where the openings for the heating elements may be used for cleaning purposes, such openings will meet the intent of the requirement of Par. M-11 of the Code for washout openings.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Clemens Herschel's Invention of the Fall Increaser

TO THE EDITOR:

In the May issue of MECHANICAL ENGINEERING, I note the biography of Mr. Clemens Herschel. It may be in order to call attention to another invention which Mr. Herschel made and for which he secured U. S. Patent No. 873,435. It is the fall increaser, by means of which an artificial suction is produced under the turbine runner for the purpose of increasing its discharge and output under reduced head, so as to regain power otherwise lost. The regainer that was described in this patent applies the principle of Mr. Herschel's earlier invention the venturi meter, in that holes are drilled in the flaring portion of the venturi nozzle through which the discharge from the turbine is drawn in.

Mr. Herschel made tests at Holyoke in which the efficiency of this fall increaser was found to be close to 30 per cent. These results were published by him in the *Harvard Engineering Journal*, June, 1908. The subject was also exhaustively treated in a book published in the German language in 1912 by Dr. Ernst Dübi, Graduate Mechanical Engineer, Federal Polytechnic, Zurich, and entitled "Über die Wirkungsweise des Gefällevermehrers nach Cl. Herschel in Verbindung mit einer Turbine," and which proves that the invention was based on perfectly correct hydraulic principles. Unfortunately, however, the fall increaser was not adopted in practice on account of the great installation cost due to increased excavation, for the additional flood water discharged through the throat of the device to produce the artificial suction requires considerable additional excavation, concrete work, and means for shutting off the operating water.

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MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Growing Obligations

AT THE Fiftieth Anniversary Celebration of the A.S.M.E. in April of this year much emphasis was placed upon the relations of the engineer to society and the public welfare. Recognition of the obligations and responsibilities implicit in these relationships, and of the conspicuous success with which the country's most eminent engineer had served his fellowmen, was crystallized in the institution of the Hoover Gold Medal. In his response when the medal was awarded to him, President Hoover said that while discoveries and inventions had brought great blessings to humanity they had also multiplied the problems of government. In the solving of these problems, he said, "we have need for a large leavening of engineering knowledge, and of the engineering attitude of mind and the engineering method." But while no emotion enters the determinations of the engineer, emotion is involved when they affect humanity, and because of this, great difficulties arise. While he did not advocate that all public service be turned over to the engineer, he did insist that engineers had a contribution to make to the public service and an obligation to make it.

The President's words suggest vast opportunities for the engineer. Already his importance in economic and financial circles is admitted. His services in the purely technical branches of the government have long been established. His influence as a factor in social progress and in international relations is being felt as transportation, communication, and industrialization bring about closer contacts of peoples. In the field of world politics he is destined some day to take his place because of his fitness to deal with technological problems.

Particularly interesting, therefore, will be the Charter Day Address by Owen D. Young at the University of California, printed elsewhere in this issue, in which the interplay of politics and economics in the tremendously vital problem of liquidating the war is set forth. The attitude of mind of Mr. Young toward an economic problem in which politics and human relations were involved is a splendid object lesson for engineers. Incidentally, Mr. Young's statement of what was accomplished makes delightful reading and clarifies an important subject. We are indebted to the University of California for the privilege of printing the address.

Aircraft Materials

AN ABSTRACT of the symposium on aircraft materials as presented and discussed at the A.S.T.M. meeting at Atlantic City in June is published elsewhere in this issue. Certain general conclusions may be drawn from this symposium, of which the first and most important is that aircraft engineers fully realize that while a very great improvement in materials has been made in the last, say, ten years, there is a vast amount of work in this direction left to be done.

An extremely gratifying feature of the meeting was the frankness with which the subject was discussed. Instead of playing the part of Pollyannas and claiming that all is well in the aircraft industry, one after another of those present got up and told about the troubles which they had encountered. Not infrequently some one else, from a competing company perhaps, was able to make practical suggestions based on his own experience. It is only by such frankness and generous cooperation that real progress can be made; and this policy is refreshing in contrast to the policy of secrecy prevailing in some other industries.

More than once it was brought out that the task of producing materials that would be satisfactory was laid upon the manufacturers of materials. Thus, for example, aircraft designers had to have steel sheet that could stand a bending test in any direction as compared to former material that could be safely bent only transversely to the direction of rolling. Steel manufacturers studied the problem and ultimately produced sheet that satisfied the new requirements. This means two things. In the first place, other than those in the aircraft industry are willing to cooperate in order to produce the best possible airplanes. In the second place, the airplane industry is already considered sufficiently important as a market to warrant the materials manufacturers' going to considerable extra trouble to secure this market.

On the whole the aircraft material symposium at the A.S.T.M. gave the impression that while a great field for improvement does indeed still exist, the aircraft industry can already boast of very important achievements and is tackling its problems in the right spirit which more than anything else gives assurance of ultimate success. Incidentally, we do not know of any meeting of any Society here or in Europe that has brought together such a representative list of good papers on the subject of aircraft materials.

It would not be amiss to refer here to the fact that the airplane *City of Chicago* remained in the air for 503 hr., a performance that would have been impossible were it not for the already greatly advanced state of airplane materials and methods of construction. It would appear, as a matter of fact, that more trouble is due to faulty installation ("plumbing" troubles) than to basic weakness of the materials and parts.

Unemployables de Luxe

WHEN as a result of such industrial changes as occur very rapidly today a bookkeeper loses his job, it is tough on the bookkeeper, but the general public seems to feel that a certain share of the fault for the resulting unemployment lies with the bookkeeper himself, namely, his election to spend his life in a

crowded profession where admission is easy and compensation correspondingly low. But that the same thing is happening with increasing frequency to the $10,000(or more)-a-year specialist is not generally realized, and yet it is a condition that men nowadays have to face more and more. John Caesar, banker, amalgamates three or four companies with a view to reducing costs by concentration of production and management. One of the chips in this process of whittling costs happens to be James Brown, engineer. James Brown is probably around forty-five to fifty, perhaps a little older. He has been with the company anywhere from five to twenty years and has risen to the position of, let us say, chief sales engineer, which means that he has been going to the large customers of the company and showing them how to employ its products or has been estimating on jobs. It is a position requiring a good deal of knowledge, special experience, reliability, etc., and pays say $10,000 a year. With the four companies merged, instead of four sales departments there is one, and instead of four chief sales engineers there is one, with a couple of young assistants hired at moderate salaries with the expectation that they will work up to the top in due time. Brown, being a high-priced man but not the top-notch one in the four companies, is "reluctantly" released. The tragedy begins when Brown starts looking for a new place. Being a $10,000-a-year man he cannot be offered a minor position, and as he is over forty-five a younger man is preferred who will stay with the company longer and incidentally cost it less. What is more, the same process of amalgamation by which Brown is made jobless is going on through the remainder of the industry, with the result that there are several other men with Brown's qualifications who are looking for jobs, while the number of jobs has decreased.

The foregoing represents a situation which is becoming more acute as time goes on. Economies through reduction of overhead mean concentration of management and getting along with one man where previously three men had to be employed. At the same time, each June there are being released from the engineering schools hordes of ambitious young men willing to work for next to nothing in order to get a chance to rise to the top, possibly the very top from which Brown has been cast into the outer darkness. Can anything be done about this situation?

New German Flax Fiber

ACCORDING to the New York *Herald-Tribune* of July 6, 1930, a German inventor, Reinhold Geiss, has developed a new chemical process for separating the complete fibrous content of flax from the straw. It is claimed that the flax so produced is soft and lustrous and retains all of its strength. The material can be employed on weaving machines used in cotton mills and will produce a linen that is said to be cheaper than cotton cloth and of greatly superior texture.

The Geiss process consists of boiling and steeping the raw material for a short time in water to which certain chemicals have been added. The mass is then carefully rinsed and dried. This is followed by decortication and degumming, both well-known processes. The whole operation is said to take only two hours, and the inventor claims that his process yields 400 lb. of treated flax to the acre as against an average cotton yield of 170 lb.

Europe is working hard in an effort to become independent of cotton imported from America and Egypt. These efforts take three forms: The first, like the Geiss process, substitute another fiber of vegetable origin for cotton. This presents obvious advantages for Europe which has plenty of land on which flax can be raised and practically none suitable for the cultivation of cotton. The second method, as yet in rudimentary stage, attempts to produce cotton synthetically. Professor Bailey of England has already succeeded in the laboratory on a very small scale in producing sugar from its elementary compounds, water and carbon dioxide, both of which are cheap and available in ample quantities. More recently it has been shown that by a comparatively simple process (on a laboratory scale only, however) sugar can be converted into a fibrous material which may prove to be the equivalent of or superior to cotton. The process would not pay today using such sugar as is raised by natural means, because the cost of the synthetic fiber would be in excess of the natural fiber. However, should the Bailey method of making sugar be developed to the commercial stage the picture may change completely. It may be mentioned in this connection that when the Germans started work on synthetic indigo the indigo growers of India scoffed, only to see their industry pass into the limbo of obsolescence.

The third method is to develop cotton by growing it in the Asiatic possessions. In this direction the recently constructed Turksib Railroad connecting Turkestan with Siberia is of particular importance. Cotton can be grown profitably in Turkestan, but in the past large areas of land capable of growing cotton were used to grow wheat to provide food, a highly uneconomic process in a country where there is an excess of wheat and a scarcity of cotton. The new railroad will permit the importation of food products, both wheat and meat, from the vast steppes of Central Siberia, which, in turn, will make it possible to increase cotton growing by some 200 per cent.

Just how all of this will affect the American cotton-growing and textile industries remains to be seen. It would be an error, however, to believe that Rome was, Rome is, and hence Rome will always be.

Eddington in Berlin

IF TWENTY years ago any one had delivered before an organization of mechanical engineers a paper on the highest branches of astrophysics dealing with such subjects as the recreation of energy in the cosmic universe and temperatures in the central part of the sun, the general feeling would have been that it might all be very interesting but useless to a practical engineer. Not that engineers are unfamiliar with this field, for the names of at least two former presidents of The American Society of Mechanical Engineers, Mr. Ambrose Swasey and Dr. John Brashear, are as well known in the field of astronomy as they are in engineering.

Such tremendous advances are being made in physics that a clear understanding of what is happening in the universe may at any time prove to be of practical value to the power-plant engineer. It is true that such a phenomenon as the dissociation of atoms occurring in the solar laboratory requires temperatures which seem to be unbelievably high, namely, of the order of 40,000,000 deg. cent. Even should we succeed in attaining such temperatures, it would appear at first glance that we could not utilize them as there are no materials on the earth which can be used to construct a 40,000,000-deg. cent. furnace. Actually, however, the situation has a much more practical significance. In the first place, certain work dealing with superconcentrated magnetic fields has already been carried to the point where metals may be subjected to atomic stresses, said to be equivalent to 1,000,000 deg. cent., and the art of producing such superconcentrated magnetic fields is still very much underdeveloped.

Another practical possibility lies in generation of what for the lack of a better term may be called atomic energy about which there is much misunderstanding. It is well known that tremendous amounts of such energy exist in the materials that are available on every side. As Eddington points out, a big power station could run for months on the energy contained in a glass of water. The only trouble is that this kind of energy will probably

never be available in utilizable form, because it represents the result of a balanced reaction, and it is only from an unbalanced reaction that commercially available energy can be produced.

As a matter of fact, a considerable quantity of molecular energy is involved when the molecules of oxygen and hydrogen combine to form water, but this energy is not commercially recoverable. On the other hand, in an unbalanced reaction molecular energy may become available, and such is the case, for example, when a piece of sodium or potassium is thrown into water. It would appear, therefore, that, while contrary to the layman's impression energy cannot be made commercially available by changing from the complex to the simple, as, for example, from molecule to atom and from atom to electron, it is possible to produce energy by changing from the simple to the complex, or from the complex to the still more complex. If, for example, one or more additional electrons could be added to a hydrogen atom, energy in commercially utilizable form would be produced.

An interesting phase of this subject is that we are living at the bottom of an ocean containing billions of tons of a highly combustible, nay, explosive, mixture, namely, oxygen and nitrogen. Our only trouble is that we have not yet discovered how to make these elements explode.

There are a number of commercial explosives which will not go off by themselves because they require certain primers such as fulminates. If it is possible to find a primer capable of setting off the mixture of oxygen and nitrogen which constitutes the earth's atmosphere, then a source of energy at a possibly negligible cost may be obtained. Of course there is a danger that a trigger effect may take place, which means that, once set off, the explosion will automatically cause further explosions until the entire atmosphere is finally converted into nitrous acid. If this happens, the human race will be wiped out. The likelihood of such an occurrence is, however, still quite remote.

Oil and Gas Power at State College

FOR the third consecutive year, the National Meeting of the A.S.M.E. Oil and Gas Power Division was held at State College, Pa., June 12 to 14, 1930, in cooperation with Pennsylvania State College. Previous meetings had been so successful that in spite of existing business depression the attendance this year was greater than that of last year. The program had been arranged so as to combine technical and social events and attracted a number of ladies as well as men.

State College has made a delightful meeting place for the Oil and Gas Power Division. In the late spring this section of the country is particularly beautiful. The facilities for housing and feeding those in attendance, and the absence of the distracting influences that are felt in more urban surroundings tend to encourage better attendance at technical sessions and closer social contacts.

Last year's meeting was devoted to the technical and scientific phase of Diesel engineering. Much of this centered around the basic principles involved in high-speed engine design. This year's conference also recognized the importance of developments in the field of the design of engines for operation at high speeds as was shown by several papers on the formation of oil sprays. The practical features of Diesel engineering, however, were given more attention in the papers presented on this year's program.

New points of view on the subject of power supply for hotel and office plants gave rise to an extended discussion of the advantage of a combined steam and Diesel plant. This discussion brought out the fact that the engineers who were in attendance at the meeting were not blind adherents to the gas- and oil-engine cause inasmuch as acknowledgment was made that Diesel-engine power does not always prove economical under such conditions.

A second paper dealing with an important subject in a practical manner reported a study made of the comparative advantages of Diesel central stations located in the communities which they served as compared to a few larger Diesel plants equipped with transmission lines and to one large station with a transmission network designed to serve all of the communities. The surprising result indicated in the report was that the difference in cost in these three systems was minute.

A second report on oil-engine power costs prepared by a committee of the A.S.M.E. Oil and Gas Power Division was also presented. The data of last year's report were complete in many respects but the committee is to be congratulated upon the thoroughness of this year's report. While it is natural to receive such reports with some skepticism because of the suspicion that the compiler is not always impartial, the data presented by the A.S.M.E. committee is likely to be accepted as being as honest and impartial as possible. The report encouraged much discussion as to its significance, but owing to the limited number of plants covered by the statistics, the averages reported should not be understood as representing the expected costs in any specific plant.

The A.S.M.E. subcommittee on Diesel fuel-oil specifications created under the auspices of the Oil and Gas Power Division of the A.S.M.E. gave a brief résumé of the status of its activities. This committee has constructed tentative specifications for Diesel-engine fuels and various engine builders are now at work experimenting with the fuels supplied under these specifications. Such work cannot be done in a day and therefore an early solution of the committee's problem is not to be expected. There is evidence that some builders are altering the design of their spray valves so that their engines may burn heavy oil.

Of interest to engine builders were papers on the introduction of steel and aluminum parts for Diesel engines. The tendency in design is toward higher speeds, and this brings with it problems of lightness and accuracy that were not so important when speeds were held to 150 r.p.m. While many engine builders have been using aluminum parts there are indications that it will be only a matter of time before a considerable portion of engine parts will be made of aluminum alloys.

Close attention was given to the subject of the gas turbine which aroused considerable interest and discussion. This type of engine has interested engineers and designers for many years but a commercial turbine has seemed impossible. The type of turbine described in the July issue of MECHANICAL ENGINEERING and at the State College meeting incorporates an air blower with the rotor.

Other papers read at the meeting dealt with the adaptation of the oil engine to aeronautics and to such machines as the tractor and excavator.

Much of the success of this and previous meetings of the Oil and Gas Power Division has been due to the thorough and careful planning by the members of the faculty of Pennsylvania State College who have acted as hosts to the visiting engineers and arranged every detail for their convenience and comfort. As in former years, a feature of the meeting was an exhibition of oil- and gas-engine accessories.—L. H. MORRISON.

The Second World Power Conference

REPORTS of the Second World Power Conference held in Berlin, Germany, in June, indicate that it was conducted with thoughtful care that insured its success. It provided an international forum for the discussion of topics of interest to power engineers, and a meeting place for those engaged in the power industries.

The total registration of 3900 is impressive, as are also the reports that the total number of members participating in the technical meetings under the 34 sections of the Conference amounted to more than 10,000 and that the record attendance at a technical session was in excess of 1200.

Great enterprise and careful preplanning on the part of the authorities added much to the effectiveness of the Conference and to the enjoyment of those who attended it. Two months prior to the Conference 380 papers were printed in the original language of the manuscript and distributed among members. Thirty-four general reports, containing (1) a brief abstract of each paper dealt with by the report, (2) a short summary of the trend of development as indicated by the papers, and (3) topics suggested for discussion, were printed in advance in all three official languages of the Conference, i.e., German, English, and French.

A unique public address system was tried out. The attempt was made to transmit to the audience the general reports and contributions to the discussion in the other two languages of the Conference at the same time the speeches were made in the original language. The system involved a series of microphones into which the speaker and interpreters spoke simultaneously. Ear phones were provided, and by means of a selective switch, every member of the audience could listen to whatever language he understood most easily. It appears from reports of the Conference that the scheme was successful, even for the discussions that had not been prepared in advance. Because of the time saved by the scheme, 430 persons were able to take part in the discussions.

Seven general addresses were an innovation that added greatly to the unusual interest and importance of the Conference. The first of these was by Dr. Albert Einstein, on "The Physical Space and Ether Problem." H. Foster Bain, Secretary of the American Institute of Mining and Metallurgical Engineers, delivered another of these addresses which greatly pleased his hearers. His subject was "The Place of Minerals in a Power-Sustained World." Professor Eddington's address on "Subatomic Energy" also attracted much attention, as, indeed did the others.

The final report of the Conference contains the following comments on the results and deliberations of the International Executive Council:

The International Executive Council has set up on the basis of some definite proposals put before it, a subcommittee which is to submit to its next meeting in 1931, after consultation with the national committees, certain proposals promoting the rational development and increasing the usefulness of the World Power Conference. Among the principal matters regarding which recommendations are expected are proposals for avoiding in the future too voluminous transactions and for facilitating a continual exchange of power statistics and information regarding important publications between the national committees. It has approved of the decisions of the German Preparatory Committees for the Second World Power Conference to publish the Conference papers this time in 21 separate volumes divided up among the various fields concerned and of selling these separately. Volume 21 which contains the seven general addresses in their original languages is already complete.

Very satisfactory progress has been made with regard to consolidating the friendly relations with other international organizations. An understanding has been come to with the International Commission on Large Dams and the International High-Tension Conference with regard to the mutual demarcation of the fields of interest. The World Power Conference can in its future meetings count on receiving special reports of these organizations as has already been the case on this occasion in the shape of the special report contributed by the International Commission on Large Dams. Similarly at the proposal of the "Commission Mixte Internationale pour les lignes téléphoniques et les canalisations souterraines," the International Executive Council has agreed to an informal exchange of current information with them. The International Executive Council has resolved as the result of three reports kindly furnished by the International Standards Commission, the Electrotechnical Commission, and the new International Association for Testing Materials, to continue to hand over to these organizations all standardization problems falling within their scope and to suggest that these organizations decide among themselves upon the division of the work among one another.

The International Executive Council of the World Power Conference having had called to its attention certain proposals for the creation of a World Engineering Federation and also of a permanent World Engineering Congress, decided that such new organizations would result in overlapping with existing bodies and so would lead to duplication of activities and over-organization of international work.

Of the four resolutions of the Fuel Conference in London, 1928, three are in the course of being carried out. The fourth, regarding international regulation of the calorific-value problem, was brought to a final solution at a special meeting on June 20 during the Second World Power Conference. It was unanimously agreed that the World Power Conference should utilize all the resources at its disposal to induce everybody when giving data based on calorific value always to make it perfectly clear whether the upper or the lower (gross or net) calorific value forms the basis of such data. For this purpose (1) an official list of the terms used for the two values is being drawn up in all principal languages, as well as, (2) international indices for both. These definitions and indices are to be published during the current year. The international standardization organizations mentioned above are to be requested to create an international standard definition for the upper and the lower calorific value.

The International Executive Council has decided to accept the tentative invitation of Sweden and of the Scandinavian Countries and to suggest 1933 as the date of the next Sectional Meeting of the World Power Conference to be held in Scandinavia on the question of power supply of big industrial undertakings.

The third Plenary Meeting of the World Power Conference will take place in America in 1936.

The International Executive Council has gone on record that it would welcome a discussion on the advantages and the disadvantages of charging for electricity on the basis of either the kilowatt-hour or the kilowatt-year or a combination of the two. It understands that the Union Internationale des Producteurs et Distributeurs d'Energie Electrique will give consideration to including this question in the agenda of one of its next meetings.

General Results

Commenting on some general results of the Conference the report says:

The World Power Conference visualizes as the method by which power may be cheapened the reduction of the cost of power generating and distribution plants by the numerous methods of a technical and executive character described at the present meeting, and secondly by increasing the number of full-load annual working hours of these plants. All papers and discussions, practically without exception, directly or indirectly dealt with these two aims which in fact formed the general theme of the Second World Power Conference.

The Second World Power Conference has moreover shown that the supplying of the world with mechanical power, light, and heat must in the long run lead to a reduction of unemployment. The tendency of power supply is to multiply from year to year the methods by which raw materials are transformed into finished products. Every new method is accompanied by new possibilities of work. Every new method requires in its turn new products for carrying it out and thus increases the markets for the products of labor. This increase in the possibilities of work is proved by the experience during the last 150 years to be greater than the reduction of the demand for physical labor due to the machine, for otherwise the population of the civilized countries could not have increased at such a rate during this interval.

Problems in Engineering Education

Observations on the 38th Annual Meeting of the S.P.E.E.

ENGINEERING education continues to show signs of greater growth and greater importance. The number of schools and colleges offering courses in engineering and the registration in these institutions have reached impressive figures indicating that there are probably 70,000 students receiving this form of instruction in this country. Significant too are reports that no difficulty is experienced in placing graduates of engineering courses and that, in some of the better-known institutions, competition for the services of these youngsters is so keen that choices must be made of several tempting offers. The indications are, therefore, that the bread-and-butter value of the training received is beyond question.

The reasons are not far to seek. This is a prosperous and progressive industrial age in which the services of trained men having a wide variety of talents can be utilized almost without limit. Industry itself depends so largely on technology, science, and engineering that its successful development demands a knowledge of these basic elements on the part of those who direct its progress. From the graduates of engineering schools are recruited the specialists upon whom industry depends.

But while mathematics, chemistry, physics, mechanics, and other fundamentals of an engineering education are becoming more and more essential to the progress of industry and those who guide its fortunes, the high degree of specialization and the great complexity of its technical features have given men with the proper training an unusual opportunity to rise to positions of the highest importance, and the urgency of the situation has often forced them from the role of the technologist to that of executive. Such a transformation of function demands that engineers be equal to such emergencies and that broader training and greater versatility than were expected of the former specialist be acquired in engineering schools. Furthermore, those who undergo this educational process must have the capacity for leadership and a point of view that transcends the preeminently technical aspects of these specialties. They must reevaluate specialties in economic and sociological terms and obtain as proper a perspective of the more complete problem as they formerly had of the details of technicalities. They must accustom themselves to the less easily predictable results of reactions under complex conditions in contrast to precise solutions with which a knowledge of natural laws has made them familiar. They must learn to give weight to imponderables, and to find reason in the apparently irrational.

It is encouraging that engineering educators themselves have been sensitive to the increasing obligations and responsibilities laid upon the men they have graduated and have persistently investigated their own obligations and responsibilities. Through the Society for the Promotion of Engineering Education they have organized their activities for the improvement of their profession, and it is a credit to them that the inspiration and enthusiasm for this work have come largely from themselves. At the 38th annual meeting of this society, held in Montreal, June 24 to 28, there was abundant evidence of these facts, and that engineering education is progressing satisfactorily and expanding widely.

President Rees' Address

While the general topic of the meeting was "The Teacher and His Work," other aspects of the problems which these men are facing were discussed. President R. I. Rees, for example, in his address, excerpts of which are to be found elsewhere in this issue, made a forceful plea for engineering leadership, and did not hesitate to call attention to certain fields in which the engineer had, as yet, made little progress, but where his services were grievously needed. In particular he spoke of the need for giving the same attention to the problem of distribution that the engineer had given so successfully to production. In referring to the problem of unemployment he called for an earnest consideration of it by engineers and asked, "Will the time ever come when no worker will have to seek for a job, but simply ask where it is?" In dealing with both of these subjects, President Rees emphasized the peculiar fitness of the engineer to deal with them, and also his responsibility to society to offer solutions.

Specifically he reminded his audience that as developers of the world's future leaders they had an important role in engineering leadership which they could fortify through fundamental research, and closed by stating that the constant, enduring, and ever-present inspiration for the teacher lay in his work.

Personal Relations of Teachers

Quality in the teaching profession cannot be insisted upon too forcefully, nor can it be too zealously maintained. There should be no opportunity for mediocre men to enter the profession nor to stay in it for the many reasons that result in the dispirited and ineffectual teachers sometimes found on college faculties. Only the best will do. To sound knowledge and reputation must be added a nobility of character and a sensitiveness to human relations that make the man an example and an inspiration to his students. To find and to hold such men for the teaching profession is a problem of major importance, not only to the institutions but to society as well, and every encouragement should be given so that the standards of this important profession may continue to higher and higher planes.

Evidence that the S.P.E.E. is concerned with this problem was shown on Friday morning at a session devoted to the personal relations of teachers. These relations were discussed under the following headings by the speakers named: "With Fellow Members of the Faculty," by J. W. Barker of Lehigh University; "With Students," by C. L. Kinsloe of Pennsylvania State College; "With the Community," by Gen. C. H. Mitchell of the University of Toronto; "With Industry," by E. E. Johnson of the General Electric Company; and "With the National Engineering Societies," by Calvin W. Rice, secretary of The American Society of Mechanical Engineers.

Mr. Rice showed that the engineering societies are keenly aware of their opportunities and responsibilities in the problem of engineering education and in the quality of men recruited for the teaching profession, and pledged the services of these societies in a cooperative study with the S.P.E.E. of the problems of mutual obligation and opportunity. He urged membership in the S.P.E.E. as an essential contact for teachers and also membership and active participation in the engineering societies. He made a plea that some plan be worked out whereby teachers could attend meetings of professional engineering societies with the encouragement and financial assistance of their institutions.

The engineering societies are fortunate in having among their members and on their numerous committees many teachers in engineering schools, and these men are frequently seen at engineering meetings. The mutual benefits of these connections should be extended, however, particularly to the younger men

who are in greatest need of the broadening influences of these contacts. If the alumni of educational institutions cannot, in all cases, offer financial assistance to the harassed deans, they can at least provide moral backing and encouragement by creating a sentiment favorable to closer contacts of faculty members with engineering-society activities.

MANY SUBJECTS DISCUSSED

That the engineering curriculum is broadening and that subjects other than the physical sciences are enjoying their day in the sun was proved by the many addresses and discussions that filled the three days of the meeting. Cooperative engineering education was discussed at a joint session of the S.P.E.E. and the Association of Cooperative Colleges. Much interest was aroused by the discussion, "Can Industrial Engineering Be Taught?" and by the conference on English. At the annual dinner, E. R. Weidlein, director of the Mellon Institute of Industrial Research, University of Pittsburgh, spoke on "Industrial Research Methods and Workers," and W. W. Colpitts, consulting engineer of New York, gave an address on "Engineering and Finance." On Friday afternoon at the Sulpician Library of L'École Polytechnique, Dr. Leo Pariseau gave a splendid lecture on "The Contribution of the Electrical Engineer to Medical Science."

Besides these features there were sessions devoted to drawing, electrical engineering, machine design, mathematics, mechanics, mining and metallurgy, the institutional division, and research; papers on "Aerial Surveying and Mapping," by S. D. Sarason, Syracuse University; "Measuring the Product of Engineering Schools," by D. B. Prentice, Lafayette College; "Technical Institute of Canada," by Augustin Frigon, Director-General of Technical Education for the Province of Quebec; "Technical Institute Education in the United States," by Robert H. Spahr, General Motors Institute of Technology; addresses by Aurelien Boyer of L'École Polytechnique and Sir Arthur Currie of McGill University; and reports of various committees.

INDUSTRIAL RELATIONS

An evening of especial interest and value was devoted to the report of the Committee on Industrial Relations of the Institutional Division, R. L. Sackett, chairman. The report, after a brief introduction by Dean Sackett, was presented by Elliott D. Smith of Yale University. The subject was, "Can the Engineering Student Be Taught to Manage Men?" Professor Smith's answer to this question was a categorical negative; but the dramatic presentation of the report and Professor Smith's explanation of the methods which he used in his course at Yale left his hearers with the impression that some of the elements of the subject could be taught by men like himself who had a thoroughly practical and experiential knowledge of the subtleties of human nature, a sufficient fund of actual cases to use as illustrative material, and an ability as a teacher to make vicarious experiences, sympathetically interpreted in the classroom, awaken in the student a sensitive and speculative attitude toward human relations.

He was opposed to the introduction of courses in "personnel management" for all engineering students inasmuch as it was not the intention of the school to make personnel managers of all its graduates. Such courses should be confined to those specializing in this work. He was positive in his belief, however, that in whatever branch of engineering a student pursued, the development of ability to deal with men would be of primary value. He cited instances of failure of otherwise brilliant men because of deficiencies in this ability, and pointed out that the danger of overlooking the human aspects of the lessons of experience was especially great with young engineers because their attention was so consistently directed to the material aspects of engineering. However, he showed, experience was haphazard and rarely was it that the errors were made clear for which punishment was exacted. This made the classroom discussion and actual handling of typical personnel situations a valuable preparation for industrial life.

The report included suggestions for teachers of courses in managing and dealing with men, suggestions for a discussion course, for a lecture course, arrangements of subjects and reading, and a bibliography of reading material.

The discussion which followed was led by Sam A. Lewisohn.

DATA ON EDUCATIONAL PROGRESS

Prior to the meeting there had been distributed to members of the society the "Report of the Investigation of Engineering Education," which was conducted by the S.P.E.E. under a grant of funds from the Carnegie Corporation and which covered a period of years from 1923 to 1929. The individual reports contained in this volume of more than 1000 pages have been available to the engineering colleges for some time, and during the past year a check-up on the effects of the report was made by means of a questionnaire. The statistics resulting from the questionnaire were presented at Montreal by F. L. Bishop, Secretary, S.P.E.E. Interesting and important as these data are, it is impossible to reproduce them here, or to evaluate them satisfactorily.

PRESENTATION OF LAMME MEDAL

The presentation, at the annual dinner, of the Lamme Medal, to Charles F. Scott, Professor of Electrical Engineering, Yale University, was an impressive and delightful feature of the meeting. The Lamme Medal is awarded by the Society each year for accomplishment in technical teaching or actual advancement of the art of technical training. The medal was established through a bequest by the late Benjamin Garver Lamme, formerly chief engineer of The Westinghouse Electric and Manufacturing Company, with whom Professor Scott had been associated. In accepting the medal, Professor Scott spoke reminiscently of his association with Mr. Lamme.

ELECTION OF OFFICERS

The following officers of the Society for 1930–31 were unanimously elected at the conclusion of the presentation of the report of the nominating committee by its chairman, Prof. D. C. Jackson:

For president, H. S. Boardman, president of the University of Maine, Orono, Me.; for vice-presidents, C. F. Harding, head, School of Electrical Engineering, Purdue University, Lafayette, Ind., R. A. Seaton, dean, Division of Engineering and director of the Engineering Experiment Station, Kansas State Agricultural College, Manhattan, Kan.; for secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa., who has held this office since 1914; treasurer, W. O. Wiley, president, John Wiley & Sons, Inc., New York, who has served in this capacity since 1907; for members of council, R. E. Doherty, consulting engineer, General Electric Company, Schenectady, N. Y., Augustin Frigon, Director-General of Technical Education for the Province of Quebec, Montreal, Canada, J. E. McDaniel, professor and director of cooperative courses, Georgia School of Technology, Atlanta, Ga., T. S. Hoover, dean, Engineering School, Stanford University, Stanford University, Calif., F. V. Larkin, director of mechanical and industrial engineering, Lehigh University, Bethlehem, Pa., W. E. Farnham, Tufts College, Tufts College, Mass., and L. E. Akeley, dean of the College of Engineering, University of South Dakota, Vermilion, S. D.

The society will hold its annual meeting at Purdue University in 1931.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Group Incentives

GROUP INCENTIVES. By C. C. Balderston. Cloth, 6 × 9 in., 172 pp., Univ. of Penn. Press, 1930, $2.50.

REVIEWED BY CHARLES W. LYTLE[1]

WHEN an author takes the pains to collect actual facts and when twenty-two executives take the pains to answer his twenty-six questions, the resulting book is bound to be of value. The publication of these answers in full, in Appendix D, pp. 128–163, is in itself a real contribution; in fact, the writer thinks this feature should have been given more prominence. Dr. Balderston has favored the descriptive form of presentation rather than the use of comparative tables, and clarity is thereby sacrificed somewhat to easy reading. This method involves excessive repetition of company names and some repetition of material. The different issues are, however, segregated, so that any reader wishing to know the practice of different companies can find sample citations gathered on each issue. The questionnaire data do not seem to be all included in these citations.

Personally, the writer thinks that group treatment has gone too far—that managers are trying to copy the automotive industry whether or not they have the same conditions. It is therefore reassuring to find that the shortcomings of the group are presented as well as the advantages. "Both group and individual incentives are needed, the one for *interrelated* and the other for *independent* jobs." "The danger to the welfare of the employees lies not in the use of group incentives, but *in their misuse.*" The misuse which to be feared, however, is the attempted application to unsuitable conditions. We no longer fear "trickery" or "temptation to cut rates" as much as the author seems to fear them.

A more serious criticism may be made in regard to fallacious thinking. The author interprets the superior balance of progressive production as meaning more accurate tasks for groups. Accuracy in task making is a matter of refinement in the measurement of the one best way of performing work. Of necessity this involves the "capture" of skill, the skill of the best individuals. If a group is to be composed of less than the best performers, as it usually must be, at least in part, the group task does not need to be extremely accurate to meet the group average of skill. As a matter of fact, the kind of task setting usually done in group treatment is crude compared with what is usually done in individual treatment. As Frank B. Gilbreth was fond of saying, "an average can be no more accurate than the data from which it comes."

Again, the assumption that average responses to different incentive plans might be identical at task or some point above task (par) is contrary to the basic principle of incentives. We do not fix a single response point and then work back through different earning plans to whatever starting points may result. On the contrary, we initiate the earning plans in order to secure responses, and the responses are bound to vary with the varying incentives. That is why we try different plans. The fallacy of the former premise was exploded years ago.

Dr. Balderston wisely limits his survey of incentive plans to seven, which he finds most commonly applied to groups. He might even reduce them further because his piece rate is taken as identical with that used by Gantt, Wennerlund, and Bedaux above task. The latter, by the way, is rarely piece rate to the direct producer. The figures and curves given for the Emerson plan do not agree between 90 per cent task and 100 per cent task. The Rowan plan was not designed for high task, and the "standard time" plan here given is identical with the Emerson plan. The term "standard time" seems to have run amuck. Most incentive plans are concerned with standard or task time. As a plan name, therefore, "standard time" is meaningless. Its best use is to describe the plan in which there are two time earnings, one either side of a standard. The Westinghouse executives have, however, made it well known as applied to a modified Gantt plan, the above-task portion of which is a 1.12 piece-rate earning, figured in hours allowed. The present designation is neither of these but an earning which is above but only parallel to basic piece rate. Some of these troubles might have been seen and avoided had the author used a full chart instead of starting from the point (65,40) or (65,80) referring to a standard percentage scale on the ordinate, which is also dropped in favor of an hourly earning scale.

Word formulas are given and terms are defined, but to an engineer the book seems loose in both plan and treatment. The paragraph headings are somewhat to blame for this, as they are far apart and do not lead on logically from one to the next. Too little emphasis is given to overhead costs, and some of the important principles are wholly lacking. Wage plans are mathematical, complex, and full of subtle variations. If they are not treated in an analytical way and made readily comparative, they are confusing. The group problem, although a small subdivision of the whole field, is of increasing importance. What is needed is a clear presentation of actual practice and a formulation of the principles of correct practice. In so far as

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the present book contributes toward these two needs, and it does contribute toward both, it is worthy of study.

Books Received in the Library

ADVANCED MATHEMATICS FOR STUDENTS OF PHYSICS AND ENGINEERING. By D. Humphrey. Oxford University Press, New York; Humphrey Milford, London, 1929. Cloth, 6 × 9 in., 2 vols. in one. $4.25.

This textbook is based on the work done at the London Polytechnic in the fourth- and fifth-year courses by students preparing for Advanced National Certificates in mechanical and electrical engineering. It aims to give students a knowledge of the principles of as many of the branches of mathematics required in their other subjects as is possible in a book of reasonable size.

APPLIED MECHANICS. By Alfred P. Poorman. Third edition. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 306 pp., diagrams, $2.75.

A textbook for undergraduate students of engineering which makes large use of graphic methods and contains many illustrative examples. The new edition has been rearranged and contains additional examples.

ARTICULATED LOCOMOTIVES. By Lionel Wiener. Richard R. Smith, Inc., New York, 1930. Cloth, 6 × 9 in., 628 pp., illus., diagrams, tables, $10.

Although based on the author's "Locomotives Articulées," two-thirds of this book is new matter, the preface states. The book discusses articulated and semi-articulated locomotives, locomotives with auxiliary or booster engines, and methods of utilizing the tender weight for propulsion. Data and drawings are given for many types, both current and obsolete, in unusual detail. A chronological list of progress in this field, a list of railroads using articulated locomotives and a directory of builders are included. The book is more complete than any other similar text in English.

AUFGABEN AUS TECHNISCHER MECHANIK. Statik Festigkeitslehre Dynamik. By L. Föppl. R. Oldenbourg, Munich and Berlin, 1930. Cloth, 7 × 10 in., 188 pp., illus., 15 r.m.

Contains 195 examples illustrating practical applications of mechanics in mechanical, electrical, and structural engineering, and applied physics. Answers are given, and many complete solutions are included. The book is intended to give students practice in the use of technical mechanics.

AUTOMOBILE STEELS. By Albert Müller-Hauff and Karl Stein. Translated from the German by Hans Goldschmidt. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 219 pp., illus., tables, $3.50.

This book aims to bring together in usable form the information about steel which is wanted by those engaged in automobile construction or in supplying steel for the industry. The translator has added the American standards for automobile steel and revised the tables of analyses of automobile parts. The work is a useful presentation of the requirements for automobile material.

CALCULUS. By Egbert J. Miles and James S. Mikesh. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 638 pp., $3.75.

This introduction to calculus is marked by a number of alterations from the traditional method of presenting the subject. The concepts of functionality and functional behavior are given a positive content and made the basis of the further developments. By means of the idea of the rate of change, the student is led from this introduction into the chief processes of both differential and integral calculus.

DIE-CASTING PRACTICE. By Marc Stern. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 8 in., 270 pp., illus., $2.50.

Intended for makers and users of die castings. The applications of die castings and their design, the design and construction of dies, suitable alloys, die machines, production methods, finishes, and the limitations and possibilities of the process are discussed.

HEAT POWER. By Earle B. Norris and Eric Therkelsen. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 376 pp., illus., $3.50.

An introductory text for students of engineering, which aims to emphasize fundamental principles rather than current practice or mechanical details. The book departs from the usual arrangement by beginning with the internal-combustion engine, as more familiar to the modern youth than the steam engine.

IDRAULICA, Vol. 1. By Giulio de Marchi. Ulrico Hoepli, Milan, 1930. Paper, 7 × 10 in., 560 pp., illus., diagrams, 80 lire.

The first of two volumes covering the course in hydraulics given at the Royal School of Engineering, Milan. This volume discusses fundamental principles, hydrostatics, the flow of water in open and closed channels and underground, and the dynamic action of currents. Numerous bibliographies are included.

KOHLENSTAUBFEUERUNGEN. By Hermann Bleibtreu. Second edition, enlarged. Julius Springer, Berlin, 1930. Cloth, 6 × 9 in., 495 pp., illus., diagrams, tables, 39 r.m.

The new edition of this comprehensive report on pulverized coal has been entirely rewritten and enlarged, so that it is again representative of recent practice. The principles of firing and the preparation of powdered coal occupy the first half of the book. The remainder is devoted to the use of pulverized coal in special industries, such as steel works, puddling, rolling mills, foundries, and smelters; and for firing locomotives and stationary boilers. Much of the material refers to American practice.

MATERIALS OF ENGINEERING CONSTRUCTION. By Francis W. Roys. Ronald Press Co., New York, 1930. Cloth, 6 × 9 in., 331 pp., illus., tables, $4.

A practical textbook covering the characteristics and properties of the most used materials in a comprehensive manner, yet not too lengthy to be used as a text for students of engineering. The explanations and descriptions are brief and direct, current developments are considered, and the illustrations are numerous and useful.

MITTEILUNGEN DES INSTITUTS FÜR STRÖMUNGSMASCHINEN DER TECHNISCHEN HOCHSCHULE KARLSRUHE, No. 1. Edited by W. Spannhake. R. Oldenbourg, Munich and Berlin, 1930. Paper, 8 × 11 in., 85 pp., illus., diagrams, 8 r.m.

The first number of a new serial devoted to the work of the Institute, which is primarily interested in the investigation of turbo-machinery.

This issue contains a brief description of the equipment for investigating turbines and pumps, and reports on one purely theoretical and two experimental investigations. Two of the latter deal with the theoretical potential flow through a turbine wheel and its comparison with the actual flow. The remaining paper describes the construction and use of a new apparatus for measuring the forces on the blades of a turbine.

MODERN LIGHTING. By Frank C. Caldwell. Macmillan Company, New York, 1930. Cloth, 6 × 9 in., 386 pp., illus., diagrams, $4.25.

A textbook on illumination as practiced today. The requirements for good lighting; light sources; light modification; lighting systems and their design; proper lighting for shops, schools, homes, streets, etc.; light projection; radiation and

color are discussed in a concise way, with enough detail for ordinary needs, but without overloading the book.

NACHTRÄGE ZUM WERKSTOFFHANDBUCH "NICHTEISENMETALLE," No. 1. Herausgegeben von der Deutschen Gesellschaft für Metallkunde in V.D.I. Beuth-Verlag, Berlin, 1929. Loose leaves, 28 pp., 3.50 r.m.

"Non-ferrous metals" was published by the German Metallographic Society and the German Engineers' Society in 1927, to meet the need of industry for a handbook of theory and practice. The present sheets, arranged to be inserted in the original loose-leaf book, contain accounts of important new investigations. Among the topics treated in these nine supplements are investigations of the ductility and resistance to internal pressure of metals, the mechanical structures of brass, the behavior of zinc-copper alloys at high temperatures, amalgams, cobalt, and the platinum metals.

PIPING HANDBOOK. By J. H. Walker and Sabin Crocker and others. McGraw-Hill Book Co., New York, 1930. Fabrikoid, 5 × 7 in., 763 pp., illus., tables, $5.

This book brings together in convenient form a large amount of information on the properties of fluids, the metallurgy of pipe materials, apparatus, and piping for many purposes, frequently wanted by engineers interested in piping work in power plants, distributing systems, and factories.

PRAKTISCHE ERGEBNISSE AUF DEM GEBIETE DER FLUGASCHE-BESEITIGUNG UND STAUBMESSUNG. By Fachausschuss für Staubtechnik beim V.D.I. V.D.I. Verlag, Berlin, 1930. Paper 6 × 8 in., 40 pp., illus., table, 4 r.m.

Five papers presented at a meeting of engineers and others interested in the dust and smoke problem, held at Dortmund last winter. One paper deals with the shape of dust and ash particles. Two articles describe experience with apparatus for measuring flue dust. The remaining two papers deal with the results obtained in two large installations for removing dust from flue gases.

QUESTIONS AND ANSWERS ON DIESEL, SEMI-DIESEL, AND OTHER INTERNAL-COMBUSTION ENGINES, AIR COMPRESSORS, ETC. By John Lamb. Third edition. Charles Griffin & Co., London; J. B. Lippincott Co., Philadelphia, 1929. Cloth, 4 × 7 in., 340 pp., $6.

A catechism of Diesel-engine operation, designed for marine operating engineers and as a preparation for Board of Trade examinations for licenses.

REGELN FÜR DIE PRÜFUNG VON WÄRME-UND KÄLTESCHUTZANLAGEN. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 11 in., 16 pp., tables, 4 r.m.

A standard code for delivery tests of heat-insulation materials, sponsored by the Verein Deutscher Ingenieure. Methods of calculating heat losses, guaranties, and methods for testing insulating materials are described. A bibliography is included.

S.A.E. HANDBOOK. 1930 edition. Society of Automotive Engineers, New York, 1930. Fabrikoid, 4 × 7 in., 728 pp., illus., diagrams, tables, $5.

The new edition of the Handbook contains the current standards and recommended practices of the Society and the specifications now in force. Over six hundred specifications are included.

STATISTICAL TABLES AND GRAPHS. By Bruce D. Mudgett. Houghton Mifflin Co., Boston, 1930. Cloth, 5 × 8 in., 194 pp., illus., $1.75.

An elementary textbook of statistical methods intended for those who plan to become business men, not statisticians. Emphasis is directed to those elementary statistical methods, the preparation of tables of figures and graphs, most used in business.

SPERRWERKE UND BREMSEN. By Richard Hänchen. (Einzelkonstruktionen aus dem Maschinenbau, heft 7.) Julius Springer, Berlin, 1930. Paper, 8 × 11 in., 94 pp., illus., diagrams, tables, 9.60 r.m.

Designers and builders of machinery, especially cranes and hoists, in which locking devices and brakes are used, will find this work useful. It affords a comprehensive description of the various devices used for stopping and controlling speed, with the formulas and constants wanted by designers.

STRENGTH OF SHAFTS IN VIBRATION. By J. Morris. Crosby Lockwood & Son, London, 1929. Cloth, 7 × 10 in., 191 pp., diagrams, 30s.

A record of mathematical researches by the author into various problems connected with the investigation of vibration in shafts. The main features of the work, the author states, are the elegant general mathematical results obtained for any number of loads on a shaft in vibration, whether lateral or torsional. The general theory is first dealt with, after which are given a number of examples illustrating the use of the methods in examining the resonant speeds of an airscrew, a dynamometer rotor, and an internal-combustion-engine crankshaft; and the vibrations in engine-driving airscrews.

STRÖMUNGSWIDERSTAND UND WÄRMEÜBERGANG IN ROHREN. By R. Hermann and Th. Burbach. Akademische Verlagsgesellschaft, Leipzig, 1930. Paper, 7 × 10 in., 88 pp., illus., diagrams, tables, 780 r.m.

Contains reports on two independent, but related, experimental investigations carried out at the University of Leipzig. The first deals with a determination of the laws of resistance to flow in circular pipe for higher Reynolds' numbers and longer lengths of pipe than heretofore investigated. It also presents new and more accurate methods of measurement.

The second paper investigates the passage of heat to pipe walls. The influence of various factors was determined, and the accuracy of accepted formulas investigated.

DAS TECHNISCHE LICHTBILD. By George v. Hanffstengel. V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 114 pp., illus., 5 r.m.

The usefulness of lantern slides and moving pictures to illustrate technical lectures depends upon the skill with which the drawings and photographs are prepared from which they are made. This little book discusses the various questions that affect the value of lantern slides and the ways in which they can be used in education and industry. Much good practical advice is given, based on experience. The book should also be useful to illustrators of technical literature and advertisements.

DIE TECHNISCHEN UND WIRTSCHAFTLICHEN GRUNDLAGEN FÜR DIE GEWINNUNG VON GEZEITENENERGIE. By Walter Stürzenacker. V.D.I. Verlag, Berlin, 1929. Paper, 9 × 12 in., 52 pp., illus., diagrams, map, 7 r.m.

An investigation of the possibility of utilizing tidal power. The author reviews the history of the question, calculates the power available, describes the schemes proposed for using it, and compares them. He also investigates the economic questions involved. His conclusion is that there are no technical or economic obstacles to success under suitable conditions.

DAS WASSERSCHLOSS BEI HOCHDRUCKSPEICHERANLAGEN. By Otto Streck. Julius Springer, Berlin, 1929. Paper, 7 × 10 in., 75 pp., diagrams, 9.50 r.m.

A discussion of surge-tank design, which aims to present the necessary formulas and data in a convenient form. Considers all the usual forms.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of Applied Mechanics, Hydraulics, and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

APPLIED MECHANICS PAPERS

A NEW HIGH-SPEED FAN. By Carl J. Fechheimer. [Paper No. APM-51-20]

The author describes a centrifugal fan of novel construction for use on steam-turbine-driven generators. In the impeller, straight blades of sheet metal are bulged with respect to a plane passing through the longitudinal axis, and are riveted to the supporting rings. Further to reduce stresses, the blades are made of duralumin, having low density and good physical properties. A partition ring lowers the stresses still more. An analysis of the stresses set up in operation is given, as well as test data of an experimental fan built to deliver 50,000 cu. ft. of air per min. and having a peripheral velocity of 25,500 ft. per min. at 1800 r.p.m. The experimental fan was run up to 83 per cent overspeed.

VIBRATION DAMPING, INCLUDING THE CASE OF SOLID FRICTION. By A. L. Kimball. [Paper No. APM-51-21]

The idea of logarithmic vibration decrement is briefly reviewed and several ways of expressing it and finding it are given.

The simple case of a vibrating reed is treated, three kinds of damping being considered—(1) an external liquid damping, (2) a liquid viscosity damping within the spring, and (3) solid damping within the spring whereby the dissipation per cycle is independent of frequency but depends upon amplitude squared.

These cases are discussed both for free vibrations and sustained vibrations.

A method is given for analyzing solid-damping vibration problems which is of general application to all cases of vibration that can be treated on the assumption of an ideal viscosity damping.

The discussion of vibration damping given herewith presents methods which have been used by the author for several years past in vibration work.

PRACTICAL DETERMINATION OF TORSIONAL VIBRATION IN AN ENGINE INSTALLATION WHICH MAY BE SIMPLIFIED TO A TWO-MASS SYSTEM. By Frederic P. Porter. [Paper No. APM-51-22]

This paper gives a practical solution for the torsional vibration in the shafting of a reciprocating-engine installation which may be reduced mathematically to a simple two-mass system. It presents methods for computing the damped vibrations in installations where the damping forces follow various laws. Particular attention is given to such damping forces as are caused by a marine propeller, elastic hysteresis, and a friction damper. The paper is illustrated by examples of computations for certain engine installations that have been investigated.

TURBINE VIBRATION AND BALANCING. By Thomas C. Rathbone. [Paper No. APM-51-23]

The author discusses the limitations of the latest analytical methods employed in correcting the balance of turbine-generator rotors at speed and in operation. A strobo-vibroscope developed to study motion in a complex system is described, with the results of experiments made on a large rotor by means of this instrument. A method of balancing is then described, which takes into account the interaction of vibratory impulses communicated from one bearing to another, thus overcoming the chief difficulty with present methods. The proposed method also provides a means for evaluating the sensitivity of any installation, for comparative study of structures. There is also included a discussion of various factors other than simple unbalance which affect the vibration of large units, with references to some unusual cases encountered.

STRESS DISTRIBUTION AND HYSTERESIS LOSSES IN SPRINGS. Progress Report No. 4 of the A.S.M.E. Special Research Committee on Mechanical Springs (Technological). By M. F. Sayre and Anthony Hoadley. [Paper No. APM-51-24]

The present report covers the first year of investigations carried on by the Committee at Union College, Schenectady, New York. The purpose of these investigations is to examine more closely than heretofore the fundamental characteristics of spring action in order that more reliable constants for a code of design on mechanical springs may ultimately be established. The experiments were conducted by Anthony Hoadley under the direct supervision of M. F. Sayre. Certain of the results were covered in Progress Report No. 3, which report was not published. It should be considered as a progress report, in that, while a number of valuable results have been obtained, the field opened up is so wide that much of the work must be considered as preliminary only.

HYDRAULICS PAPERS

PROGRESS IN HYDRAULICS. [Paper No. HYD-51-11]

This report, contributed by the A.S.M.E. Hydraulic Division, reviews progress during 1929, and deals successively with factors affecting the economics of hydroelectric power development; governmental regulation and supervision of utilities and structures; governmentally owned hydro plants and projects; model testing; dams and accessories; water measurement; adjustable-vane, propeller-type, impulse, and reaction turbines; generators; frequency and load control; penstocks; pumps; fish screens, fishways; and hydrology.

AN INVESTIGATION OF A ROTARY PUMP. By Frank V. Bistrom and William W. White. [Paper No. HYD-51-12]

This paper, which received the A.S.M.E. Student Prize Award for 1929, describes tests of a 1½-in. horizontal-shaft rotary pump carrying three rectangular vanes and having, when running at 800 r.p.m., a capacity of 40 g.p.m. The effect of "hammer" on output and input at various heads is discussed, and a remedy found for hammering.

MECHANICAL VIBRATIONS IN PENSTOCKS OF HYDRAULIC-TURBINE INSTALLATIONS. By J. P. Den Hartog. [Paper No. HYD-51-13]

In this paper the author presents a theory showing that objectionable vibration phenomena are to be expected in the penstocks of Francis-turbine installations when the number of buckets on the turbine runner is one less than the number of guide vanes, and that satisfactory operation should be obtained when this relation is avoided. Observations on eight different installations show good agreement with the theory.

WOOD INDUSTRIES PAPERS

THE COORDINATION OF PRODUCTION AND DISTRIBUTION OF WOOD PRODUCTS. By Carle M. Bigelow and Thomas D. Perry. [Paper No. WDI-51-10]

After noting that rarely have the qualities of attractive woodworking craftsmanship and methods of aggressive distribution been found in profitable combination, the authors take up problems involved in production, dealing successively with sales-dollar analysis, labor utilization, material yield, planning and budgeting, and standard costs. They then consider the distribution of wood products and discuss respectively marketing the commodity product, selling to distributors, and marketing the style product. Following this they

deal briefly with the coordination of production and distribution, and in conclusion point out the great demand at present existing for a transfer of some of the already achieved manufacturing skill into the merchandising field.

MAKING ANIMAL GLUE WATER-RESISTANT. By F. L. Browne. [Paper No. WDI-51-11]

In this paper the author gives a formula for making animal glue water-resistant. Graphs are given which show the relation between the temperature and the working life of a batch of glue when prepared by the recommended formula, and also for a glue containing paraformaldehyde without oxalic acid. Rapid decrease in the working life of both glues at high temperatures makes it necessary to control the heating of the glue carefully. Characteristics of a water-resistant animal glue are given, together with the effect of varying the content of oxalic acid and paraformaldehyde.

TOOLS FOR BORING AND MORTISING WOOD. By A. H. Hawkinson. [Paper No. WDI-51-12]

In this paper the author describes various woodworking tools for boring and mortising. A large variety of bits is required to meet the various conditions of work in the different kinds of woods. There is also a varying moisture content in woods, as some are dry while others are green. These elements introduce serious problems.

PLYWOOD CORES AS A FOUNDATION FOR GOOD WOODWORK. By E. Vernon Knight and Thomas D. Perry. [Paper No. WDI-51-13]

Plywood consists of laminated sheets of wood. The core supports the interlocking layers and the face veneer. Various manufacturing problems of plywood are discussed in this paper. The various woods used are selected for their strength, artistic figure, and workability. Some of the physical characteristics of the more usual species of woods are given. The various types of joints and the methods of matching and gluing are described, and department layouts for two plants are given to illustrate routing procedure and the types of woodworking tools used.

SCANDINAVIAN GANG SAWS FOR CLOSER UTILIZATION OF TIMBER. By Axel H. Oxholm. [Paper No. WDI-51-14]

One of the outstanding wastes in American logging and sawmill operations today is the failure to utilize top logs and small timber. The Scandinavian type of gang saw differs from the American in many respects, one of which is its ability to saw round logs. The Scandinavian gang saws are capable of producing accurately cut lumber, and through the use of spring-set saws the surface is so smooth that the lumber may be used without further sizing. The sizing process alone removes at least $^1/_8$ in. of wood and often more, and this process involves about 50 cents per thousand feet in labor charges. If such lumber could be produced for the box and crate industry alone, it would save 110,000,000 ft. per year which is now being wasted in the form of chips produced through the sizing process.

It is safe to figure on obtaining from 25 to 30 per cent more lumber from the log when gang saws are used than can be obtained when any conventional method of sawing is employed. Details of these saws and their operation are given by the author.

END COATINGS FOR LOGS AND LUMBER. By L. V. Teesdale. [Paper No. WDI-51-15]

Unequal drying of green timber and lumber causes checking and splitting. As drying under natural conditions is more rapid from the end grain than from the side grain, protection of the ends to retard the end drying is resorted to. Suitable end coatings are also effective in preventing development of stain and decay.

In this paper the author tells of studies made by the Forest Products Laboratory with various coatings and the beneficial results that are obtained by reducing the waste from end checks, decay, and stain while timber is seasoning.

DRUM-SANDER MANUFACTURE AND USE. By Richard A. Williams. [Paper No. WDI-51-16]

In this paper the author describes the essentials of some types of sanding machines, and tells how various troubles are overcome. To turn out good work the drums of a sanding machine must be rigid and run true. The abrasive paper must be held securely and the drums must have dynamic balance. Direct motor drive is now considered as regular equipment for drum sanders. Advantages of the roll-feed sander and the endless-bed type are given.

WOOD BENDING. By T. R. C. Wilson. [Paper No. WDI-51-17]

Wood softened by the action of moisture and heat or by other agencies can be upset or shortened very considerably, but can be stretched or lengthened but little. Hence, since the concave and convex faces of a bent piece differ in length, it is necessary in bending to prevent stretch and to cause the entire difference in length to take place as upset, this upset being a maximum at the concave face and decreasing to zero near the convex face. This can be accomplished by supplying a metal strap with securely attached end fittings through which the compressive force, or end pressure, can be applied. The end pressure must be distributed over the ends of the stock so that localized crushing does not occur, and the rotation of the end fitting must be restrained to obviate release of the end pressure. The common arrangement of parts of wood-bending apparatus does not fulfil these requirements. The requirements can be attained, however, by utilizing the principle of the reversed lever.

The distance between end fittings cannot be made exactly the same for a number of straps and cannot be kept constant, neither can pieces of wood be cut exactly to the required length. Hence, means for adjusting the distance between end fittings is necessary. Pieces whose width is considerably less than their depth must be restrained to prevent sidewise bending and the formation of lateral crooks and buckling.

This paper, which is based on studies at the Forest Products Laboratory, deals only with the requirements of bending apparatus and manipulation, emphasizes their importance, and points out that they must be correct before the large breakage losses incurred in the bending of wood can be reduced materially.

NOTE: Those who have not registered in the A.S.M.E. Applied Mechanics, Hydraulics, and Wood Industries Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

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AERONAUTICAL INSTRUMENTS

Artificial Horizon. The Artificial Horizon, E. A. Sperry. Am. Soc. Mech. Engrs.—Advance Paper for mtg., May 19 to 22, 1930, 3 pp., 2 figs. Description of instrument developed recently to aid blind flying; through use of gyroscope gravity device is constructed with very slow rate of motion that will maintain horizontal position in airplane with sufficient accuracy to make most useful instrument; test data for instrument are given.

AIR COMPRESSORS

High-Pressure. High-Pressure Air Compressors. Engineering (Lond.), vol. 129, no. 3353, Apr. 18, 1930, pp. 506–507, 6 figs. G. and J. Weir, Ltd., have completed series of high-pressure air compressors, for manufacture on production basis with attendant advantages of interchangeability and decreased costs; of this series, some account is given and examples are shown.

AIRPLANE ENGINES

Design. Trend in Aircraft Engine Development, H. Caminez. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. May 19–22, 1930, 10 pp. Enumeration of important factors determining performance; detailed comparison of air and water cooling; large European water-cooled engine develops one hp. per 1.2 cu. in. and weighs 0.80 lb. per hp.; difference between military and commercial engine; possibilities of Diesel cycle.

Diesel. Development of the Junkers-Diesel Aircraft Engine, Gasterstaedt. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 565, May 1930, 20 pp., 20 figs. Design and performance of 650-hp. 2-cycle engine; details of fuel injection and scavenging systems; vibration test.

Manufacture. Automotive Methods and Practices Involved in Aircraft Engines, O. E. Szekely. Am. Soc. Mech. Engrs.—Advance Paper for mtg., June 9–12, 1930, 13 pp., 6 figs. Comparison between cost of standard parts in automobile manufacturing and cost of parts in airplane manufacturing; metals that enter in automobile manufacturing can be secured in market at apparently very much lower price than when it is known they are intended for use in airplanes; relations are illustrated by formulas and graphs.

Supercharging. The Present Status of Superchargers for Aviation Engines, S. A. Moss. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 19–22, 1930, 4 pp. Review of application and possibilities of centrifugal superchargers; typical designs are illustrated and discussed; geared and exhaust drive types; manufacture at River Works of General Electric Co., Lynn, Mass.

Vibration. Vibration Characteristics of Aircraft-Engine Crankshafts, F. L. Prescott. Am. Soc. Mech. Engrs.—Advance Paper for mtg., May 19 to 22, 1930, 11 pp., 22 figs. Report on tests with recording torsiometer by Material Division of United States Air Corps at McCook Field; Dayton, O.; diagrams show record of torsional vibration of Liberty crankshaft with metal and wood propellers; method of determining acceleration from records. Bibliography.

AIRPLANES

Autogiros. See AUTOGIROS.

Design. Aeronautical Progress, 1914–1930, R. V. Southwell. Engineer (Lond.), vol. 149, no. 3878, May 9, 1930, pp. 512–514; see also Engineering (Lond.), vol. 129, no. 3356, May 9, 1930, pp. 611–613. Author maintains that kernel of present knowledge of aerodynamic theory is contained in lectures delivered in 1912 and 1914, by Mallock and Lanchester, respectively; in past 16 years safety has been attained; what mainly delays comfort is noise; aerodynamic efficiency is slightly improved in spite of increased speeds; range has been multiplied by 13, rate of climb by 3, altitude by nearly 3, speed by nearly 4; structural design has not fallen behind. Paper read before Instn. Civ. Engrs., May 6, 1930.

New Method for Aerodynamical Calculation of Propellers (Un Nuovo Metodo per il calcolo Aerodinamico Diretto Delle Eliche), U. de Caria. Aeronautica (Milan), vol. 8, no. 3, Mar. 1930, pp. 175–180, 4 figs. Mathematical computation of propeller characteristics, power requirement, air velocity, etc.

Light Alloys for. Some Characteristics of Light Alloys for Aircraft, H. W. Gillett. Am. Soc. Mech. Engrs.—Advance Paper, for mtg., May 19 to 22, 1930, 6 pp. Description of various light alloys that might be used to advantage in aircraft construction; their advantages and drawbacks; cost and data; brief notes on forging and casting. Bibliography.

Production Control. Reduction of Airplane Production Costs, J. Don Alexander. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 19–22, 1930, 2 pp. Brief outline of cost-reducing production methods of Alexander Industries Corp. at Colorado Springs, Colo.; labor-saving machinery; examples for various operations are mentioned.

Seaplanes. See SEAPLANES.

Tailless. Recent Tests of Tailless Airplanes, A. Lippisch. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 564, May 1930, 10 pp., 9 figs. Design and performance of plane with 9-hp. D. K. W. engine, developed from glider type; maximum speed 78 mi. per hr.; results of test with models in Goettingen wind tunnel. Translated from Aérophile, Feb. 1–15, 1930 previously indexed.

Wings. Creative Wing Design, R. H. Upson. Aviation, vol. 28, no. 20, May 17, 1930, pp. 989–992, 4 figs. Outline of system for coordinating various factors of design procedure; investigation of two wing combinations for light low-wing monoplanes; weight and drag data are figured and performance characteristics calculated.

Design of Tapered Monoplane Wings (Zur Berechnung von apitzendigen Eindecker-Trafluegeln), E. Amstutz. Schweizerische Bauzeitung (Zurich), vol. 95, no. 14, Apr. 5, 1930, pp. 181–186, 16 figs. Theoretical mathematical analysis of stresses in cantilever wings of the types used in Rohrbach seaplanes.

Devices for Reducing Landing Speeds (Dispositifs pour la réduction de la vitesse d'atterrissage), P. Berger. Schweizer Aero-Revue (Zurich), vol. 5, no. 1, Jan. 1930, pp. 11–13, 10 figs. Discussion of air flow, angle of incidence and influence of slot; sketches show various possibilities of slot mechanism in connection with ailerons.

AIRSHIPS

Mooring Masts. Airship Mooring-Strain Indicator. Engineering (Lond.), vol. 129, no. 3355, May 2, 1930, pp. 584–585, 4 figs. At mast in Cardington forces are transmitted through steel mooring tube, bending of which is measure of their magnitude; to measure bending two electric strain gages are mounted on outer tube which is co-axial with mooring tube but not exposed to stress; spring-controlled plungers extending radially inward from gages rest on outer surface of mooring tube, so that any bending of latter is transmitted to gages by inward or outward movement of plungers.

ALLOY STEELS

Properties. Physical Properties of Pure Chromium and Tungsten Steels (Die physikalischen Eigenschaften von reinen Chromund Wolframstaehlen), F. Staeblein. V.D.I. Zeit. (Berlin), vol. 74, no. 17, Apr. 1930, p. 541. Notes on specific gravity, specific resistance, magnetic properties, thermal conductivity and heat expansion of alloys containing about 25 per cent chromium or tungsten. Indexed in Engineering Index, 1929, p. 151, from Archiv fuer das Eisenhuettenwesen (Duesseldorf), Oct. 1929.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See BRASS.

Copper. See COPPER ALLOYS.

Iron. See IRON ALLOYS.

Light. See AIRPLANES, Light Alloys for.

ALUMINUM ALLOYS

Aluminum-Zinc. Kinetic Measurement of a Transformation Reaction in Solid Metals (Kinetische Messung einer Umwandlungsreaktion in feston Metallen), W. Fraenkel and E. Wachsmuth. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 5, May 1930, pp. 162–167, 9 figs. Results of

measurements of longitudinal change of aluminum-zinc alloys in relation to time carried out with aid of interferometer; contrary to previous theory, it is shown that reaction does not follow radioactive disintegration law, but shows self-acceleration at first; relation of speed of reaction to degree of quenching temperature is demonstrated.

Die-Casting. See DIE CASTING.

Hiduminium. Rolls Royce Develops Aluminum Alloy Termed "Hiduminium," W. C. Devereux. Automotive Industries, vol. 62, no. 18, May 3, 1930, pp. 697–698. Brief description of new alloy made by Rolls Royce, Derby, England, and its application; physical properties and composition given in table. Paper read before Brit. Instn. Production Engrs., previously indexed from various sources.

Light. Recent Progress in Light Aluminum Alloys (Les récents progrés des alliages légers d'aluminium), L. Guillet. Génie Civil (Paris), vol. 96, no. 19, May 10, 1930, pp. 449–454, 5 figs. Properties of aluminum-silicon-magnesium, and aluminum-copper alloys, also of alloys of aluminum-copper-silicon with or without manganese.

Properties. Brinell Hardness, Elastic Limit, and Tensile Strenth of Commercial Aluminum Alloys (Brinellhaerte, Elastizitaetsgrenze und Zugfestigkeit verguetbarer Aluminiumlegierungen), P. Melchior. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 5, May 1930, pp. 175–176, 3 figs. Results of author's investigation of relations between Brinell hardness, elastic limit and tensile strength, as reported by H. Bohner, indexed in Engineering Index, p. 157, from Nov. 1929, issue of same journal.

AUTOGIROS

Characteristics of. The Autogiro: Its Characteristics and Accomplishments, H. F. Pitcairn. Franklin Inst.—Jl., vol. 209, no. 5, May 1930, pp. 571–584, 9 figs. Description of development and advantages of autogiro; safety and performance, horizontal speed 120 m.p.h. with 225 hp.; vertical descent 12 ft. per second.

AUTOMOBILE ENGINES

Manufacture. Building the Franklin Airplane-Type Automobile Engine, J. Geschelin. Automotive Industries, vol. 62, no. 18, May 3, 1930, pp. 686–689 and 696, 13 figs. Description of operations and equipment at Franklin plant; manufacturing aspects of design are reviewed; data on output and tolerances are given for various machine tools and engine parts.

Mass Production Method Applied in Manufacture of Oakland V-Eight Engine, J. Geschelin. Automotive Industries, vol. 62, no. 20, May 17, 1930, pp. 764–767, and 770, 10 figs. Description of manufacturing process and equipment at Oakland Motor Car Co.; certain difficult single operations which would slow up multiple-spindle set-ups are singled out and performed on special units; foundry; new machine shop layouts.

AUTOMOBILE MANUFACTURE

Production Control. Selective Inspection Cuts Assembly Costs, W. G. Holmes. Am. Mach., vol. 72, no. 20, May 15, 1930, pp. 806–810, 4 figs. Detailed description of methods of gaging and assembling used successfully in one of largest automobile plants in United States and permitting maintenance of accurate fits without necessity of excessively close machining tolerances; group classification of shafts and bearings during inspection with convenient means for their identification is keynote of this method.

AUTOMOBILES

Transmissions. Power Losses in Transmissions Measured by Direct Tests, J. H. Hyde and F. Aughtie. Automotive Industries, vol. 62, no. 18, May 3, 1930, pp. 692–696, 9 figs. Analysis of factors determining transmission losses; sketches give arrangement of transmission and dynamometer for tests; variation of friction torque with oil temperature; diagrams show variation of friction torque with quantity of oil in case; variation of friction with speed, and of efficiency with quantity of oil in case; relation between efficiency and load in direct drive, in input shaft in second gears, and in third gear; relation between efficiency and input load in first gear. Paper read before Instn. Automobile Eng.

Universal Joints. Non-Uniformity of Universal Joint Performance (Ungleichfoermigkeit von Kreuzgelenk-Uebertragungen), K. F. Naegele. V.D.I. Zeit. (Berlin), vol. 74, no. 16, Apr. 19, 1930, pp. 506–508, 16 figs. Detailed description of experiments with universal joints of cord front-wheel-drive; comparison of results with tests of universal joints of conventional type; sketches show test set-ups using Geiger torsiograph; curves of torsiograph are given.

AUTOMOTIVE FUELS

Detonation. Anti-Detonators, W. H. Coleman. Instn. of Petroleum Technologists—Jl. (Lond.), vol. 16, no. 80, Mar. 1930, pp. 247–251. Brief review of progress during 1928–1929; much has been done in general work on action of anti-detonators and on causes of detonation or "pinking" in internal combustion engines; we still do not know exactly what detonation is or is due to, nor exactly how anti-knock dopes act when added to fuel, good work has been done but there is room for more. Bibliography.

Volatility. Effective Volatility Under Driving Conditions, J. E. Miller and G. G. Brown. Indus. and Eng. Chem., vol. 22, no. 6, June 1930, pp. 653–662, 16 figs. Definition of effective volatility under driving conditions and indication of how it may be determined from equilibrium volatility on A.S.T.M. distillation data.

Relation Between Atmospheric Temperature, Fuel Volatility, and Engine Performance, C. L. Nickols and G. G. Brown. Indus. and Eng. Chem., vol. 22, no. 6, June 1930, pp. 662–671, 14 figs. Relation of effective volatility to engine performance; A.S.T.M. distillation characteristics required for satisfactory performance under different conditions of atmospheric temperature are suggested.

B

BALANCING MACHINES

Dynamic. Flywheel Balancing. Automobile Engr. (Lond.), vol. 20, no. 267, May 1930, p. 160, 4 figs. Description of sensitive dynamic balancing machine of novel design for flywheel balancing; working principle illustrated by sketches.

BEARINGS

Friction in. Experimental Research on the Friction of Pivots, A. Jaquerod, L. Defossez, and H. Muegeli. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 566, May 1930, 54 pp., 15 figs. Report on friction experiments with horizontal and vertical pivots, dry and lubricated; graphs show influence of speed and load, viscosity and aging of oil; interpretation of results; comparison with several theories on friction. Bibliography.

Tests on Friction in Journal and Roller Bearings (Versuche ueber die Reibung in Gleit- und Rollenlagern), E. Schneider. Petroleum (Berlin), vol. 26, nos. 7 and 11, Feb. 12, 1930, pp. 221–236, and Mar. 12, 1930, pp. 337–348, 16 figs. Study is based on so-called hydrodynamic theory of bearing friction. Feb. 12: Results of main tests on journal bearings; theoretical considerations, testing methods, and equipment employed. Mar. 12: Tests on friction of roller bearings; evaluation of results. Bibliography.

Journal—Flexible. The Silentbloc Flexible Bearing. Engineering (Lond.), vol. 129, no. 3353, Apr. 18, 1930, p. 522, 5 figs. This form of bearing, manufactured by T. B. Andre and Co., consists essentially of outer and inner metal sleeve, between which are inserted bush of practically pure Para rubber.

BOILERS

Combustion Control. Automatic Combustion Control for Boiler Furnaces, G. R. Bamber. Inst. Mech. Engrs.—Proc. (Lond.), no. 5, Dec. 1929, pp. 1099–1113, 1 fig. Automatic control of combustion in boiler furnaces is departure of comparatively few years' standing; it owes its development chiefly to United States, although two noteworthy systems are due respectively to Germany and Czechoslovakia; test figures given may be regarded as typical of improvement brought about by installation of automatic control apparatus; they relate to battery of boilers at railway repair works at Cassel, Germany, fitted with Askania control.

Hagan Boiler-Control (Hagan-Kesselregelung), P. Kaufmann. Waerme (Berlin), vol. 53, no. 19, May 10, 1930, pp. 345–349, 5 figs. Hagan automatic control system and its application to large and small plants are described.

Design, France. Evolution in the Products of French Babcock and Wilcox Co. during 10 years (L'évolution dans les fabrications de la Société francaise des Constructions Babcock et Wilcox, depuis dix années). Chaleur et Industrie (Lond.), Apr. 1930 (Special No.), pp. 163–171, 19 figs. Description and sketches of various types of boilers and equipment; sectional W.I.F. boiler; marine boiler; vertical-type Ladd Belleville; superheaters; automatic stokers; air preheaters; pulverized fuel.

Furnaces, Radiation in. Some Modern Boiler Problems, Petire. Engineering (Lond.), vol. 129, no. 3358, May 23, 1930, pp. 673–674. Editorial comment on report to Manchester Steam Users Assn., dealing with radiation problem; author proposes to base theory of radiation in boiler furnaces on fact that strong absorption bands in infra-red region characterize spectra both of carbon oxide and water vapor; view accords well with experiments of Callendar and Julius; solution of high-temperature boiler problem may be as much matter of eliminating every possibility of defective circulation as it is of improvement of materials.

High-Pressure. Recent Developments of the Benson Boiler, H. Gleichmann. Power Plant Eng., vol. 34, no. 11, June 1, 1930, pp. 612–613, 1 fig. Changes in tube arrangement and shape of boiler; new 300,000-lb. per hr. unit will be in service at Langerbrugge station this summer; reheater replaced with economizers; cross-sectional view of latest Benson boiler is given; tests made with low-volatile coal.

Loeffler Boiler Developments. Eng. and Boiler House Rev., vol. 43, no. 11, May 1930, pp. 674–675, 2 figs. Boiler factory of Vitkovice Mines, Steel and Iron Works Corporation, acquired license rights for construction of Loeffler high-pressure boilers, and in 1927 first boiler of this design for output of 1500 kg. of high-pressure steam per hour for 1900 lb. and 935 deg. temperature was started in electric station of Caroline coal mine; boiler which has been in day and night operation for more than three years has proved completely claims of Loeffler steam pumping process.

BRASS

Metallurgy of. The Effects of Silicon on the Properties of Brass, H. W. Gould and K. W. Ray. Metals and Alloys, vol. 1, no. 11, May 1930, pp. 502–507, 22 figs. Description of tests for specific gravity, hardness, impact breaking strength, tensile strength, percentage elongation, and corrosion resistance made on series of brasses containing varying percentages of silicon; microphotographs, tables, and graph interpret results.

C

CADMIUM

Plating With. Cadmium as a Protection Against Corrosion (Cadmium als Korrosionsschutz), A. Siemens. Zeit. fuer Elektrochemie (Berlin), vol. 36, no. 2, Feb. 1930, pp. 101–105; see also translated article in Metal Industry (Lond.), vol. 36, no. 18, May 2, 1930, pp. 481–483. Review giving data and numerous references on production, physical and chemical properties, and methods of applying metal in form of protective coating, especially by electrodeposition.

CAMS

Differential. Differential Cam Mechanism. Machinery (Lond.), vol. 36, no. 191, May 22, 1930, pp. 233–234, 4 figs. Description and sketches of mechanism for bobbin winding machine; analysis of motion and diagram showing variation of combined throw of cams.

CARS

Passenger—Steel. On the Question of All-Steel Coaches. Comparison With Vehicles Built of Wood (Subject VIII for Discussion at the Eleventh Session of the International Railway Congress Association), D. Daehnick. Int. Railway Congress Assn.—Bul. (English Edition, Brussels), vol. 12, no. 2, Feb. 1930, pp. 635–664, 28 figs. Report covers German cars; advantages of all-metal method of construction; types of cars in service, in construction or being designed; table of recent all-steel, semi-steel, and wooden coaches.

CASTINGS

Shrinkage and Piping. Shrinkage and Piping (Schwindung und Lunkerung—Sschwindmass), W. Claus. Giesserei (Duesseldorf), vol. 17, no. 19, May 9, 1930, pp. 449–455, 20 figs. Problems of iron, steel, and non-ferrous-metal foundries; piping of tin bronze, 10:90 and aluminum bronze 10:90; simple linear shrinkage coefficient; linear shrinkage calculated from cubic shrinkage coefficient; Claus-Gooderitz theory of shrinkage; values for pure aluminum, copper, pure iron, carbon steels, and cast iron.

CHAINS

Strength of. Rings, Links, and Hooks—Discrepancies Between Theory and Practice, A. G. Thompson. Colliery Guardian (Lond.), vol. 140, nos. 3616 and 3617, Apr. 17, 1930, pp. 1463–1465, and Apr. 25, pp. 1561–1562, 7 figs. Notes on tests, mathematical discussion, graphs, and formulas; conclusion is that apparent discrepancy is definitely solved by dispersion, and that other mathematical refinements are of little practical importance.

CHROMIUM-MANGANESE STEEL

Drawing Qualities of. Rustless Chromium-Manganese Steel Have Deep-Drawing Qualities, F. M. Becket. Iron Age, vol. 125, no. 20, May 15, 1930, pp. 1468–1470, 6 figs. Description of composition and physical properties of stainless chromium-manganese steels of improved deep-drawing qualities; effect of manganese on strength, ductility, toughness, and hardness of low-carbon steel with 17 to 18 per cent chromium; composition ranges, Cr 17 to 18 and Mn 5 to 7 per cent; addition of copper increases deep drawing properties. Abstract of paper read before Am. Iron and Steel Inst.

COAL-HANDLING

Equipment for. Aerial Coal Transporter with Traveling Tower. Engineering (Lond.), vol. 129, no. 3357, May 16, 1930, pp. 629–630, 25 figs., partly on p. 638 and supp. plate. Storage plant of large capacity of aerial-transporter type has been built at pit bank of Hohenzollern coal mines of Graeflich Schaffgotschasche mines at Beuthen, Silesia, by J. Pohlig A. G.; installation embodies fixed tower with moving one working over arc.

COAL PULVERIZERS

Tests of. Grinding Tests With a Tube Mill Without an Air Separator (Mahlversuche an einer sichterlose Rohrmuehle), Grosse, Foerderreuther and Rammler. Zement (Charlottenburg), vol. 19, nos. 9 and 10, Feb. 27, 1930, pp. 189–194 and Mar. 6, pp. 214–217, 7 figs. Experiments were made to find relation between fineness, power consumption, output, load limit, and moisture of powdered coal; mill was three-compartment compeb (solo mill) mill; coal samples were taken from mill in certain time intervals for sieve analysis; it was possible to calculate composition of coal powder from single test on one standard sieve.

CONVEYORS

Pneumatic. Handling Raw Materials by Pneumatic Conveying. Ceramic Industry, vol. 14, no. 5, May 1930, pp. 541–543, and 546, 7 figs. Handling types of pneumatic conveyors are described; chief advantages of pneumatic conveying are, improved labor conditions through elimination of dust and fume hazards; reduction of labor costs through elimination of manual handling; reduction of wasted material through elimination of spillage; conservation of space through compactness of collecting station and conveying pipelines, and flexibility.

Screw. Economical Portable Screw Conveyor for Handling Sacks. Concrete, vol. 36, no. 5, May 1930, pp. 118–119, 2 figs. Description of conveying equipment by Clark Tructractor Co. consisting of two parallel tubular screws which are turned toward each other by power head; material may be carried forward at speed of 90 ft. per min.; capacity of conveyor is about 1200 sacks per hr.; joints may be turned.

COPPER ALLOYS

Copper-Nickel. British Standard Specification for Nickel-Copper (Cupro-nickel) Sheets and Strip. Brit. Eng. Standards Assn. (Lond.), no. 374, Apr. 1930, 7 pp. Standard specifications covering quality of material, chemical test, freedom from defects, dimensions, provision of test pieces, mechanical tests, re-tests, inspection, and testing facilities.

Copper-Zinc. Heat Treating of Zinc-Copper Alloys (Ueber den Verguetungsvorgang in Zink-Kupferlegierungen), M. Hansen. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 5, May 1930, pp. 149–154, 8 figs. Trend in aging of quenched zinc-copper alloys is shown in resistance-time curve; influence of temperature, composition, and speed of cooling; change in hardness of quenched alloys in relation to aging temperature and composition.

The Significance of Hardness Values for Some Copper-Zinc Alloys, C. H. Davis and E. L. Munson. Am. Soc. Testing Matls.—Advance Paper No. 49, for mtg. June 23–27, 1930, 7 pp., 6 figs. Effect of grain size on hardness of both annealed and cold-worked alpha-phase copper-zinc alloys has been observed; significance of variables which affect hardness values is shown by series of curves.

Hardening. Hardening of Copper-Silver, Beryllium-Copper, and Zinc-Copper Alloys (Beitrag zum Haertungsproblem von Kupfer-Silber, Beryllium-Kupfer- und Zink-Kupfer-Legierungen , M. Haas and D. Uno. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 5, May 1930, pp. 154–158, 11 figs. With aid of structure analysis, dilatometry, and measurement of electric conductivity, trend of hardening is followed. Bibliography.

Properties. Copper and Copper Alloys, W. H. Bassett. Nat. Elec. Light Assn.—Bul., vol. 17, no. 5. May 1930, pp. 275–278, 7 figs. Properties of copper drawing practice; copper alloys used in transmission work; tables showing comparative physical properties of steel and everdur; comparative properties copper and copper alloys; comparison of beryllium alloys with copper-tin and copper-cadmium alloys; curves showing copper-beryllium alloys and strength and conductivity of 0.125 diam. wire of 0 to 1.6 per cent beryllium.

Specifications. Report of the Special Committee on Promotion of General Use of Specifications for Copper Alloys in Ingot Form. Am. Soc. Testing Matls.—Advance Paper No. 29, for mtg. June 23–27, 1930, 3 pp. Tabulation of specifications clearly developed fact that it is possible to greatly reduce number of alloys now used in industry; there are 40 different specifications for one of most widely used alloys of industry, namely, 85 per cent copper, 5 per cent tin, 5 per cent lead, and 5 per cent zinc; it is certain that these 40 specifications could be condensed into one.

COPPER STEEL

Properties. Mechanical Properties of Copper-Bearing Steels With Special Regard to Heat Treatment (Ueber die mechanischen Eigenschaften kupferlegierter Staehle unter besonderer Berueecksichtigung der Waermebehandlung), F. Nehl. Stahl und Eisen (Duesseldorf), vol. 50, no. 20, May 15, 1930, pp. 678–686, 15 figs. Properties of copper steels; corrosion resistance; improvement in strength properties, especially yield point and heat resistance, by suitable heat treatment; dispersion hardening; use of copper steel as building material, for forgings, and for castings.

COUPLINGS

Flexible. What's What in Flexible Couplings, F. A. Annett. Power, vol. 71, no. 19, May 13, 1930, pp. 742–744, 16 figs. Continued illustrated description of several types of flexible couplings.

CRANES

Aluminum-Alloy. Crane Built of Strong Aluminum Alloy, F. V. Harman and E. F. Hartman. Iron Age, vol. 125, no. 23, June 5, 1930, pp. 1689–1690, 4 figs. Crane described is 3-motor, single-hook machine with lift of 22 ft.; bridge is fabricated from two double-web girders spaced 7 ft. on centers; girders are constructed of strong aluminum alloys and have span of 72 ft. 2 in.; aluminum was used also in walkway, handrails, and operator's cage; bridge girders frame into cast steel carriages at their end, and one-piece cast-steel trolley carrying hoisting mechanism is mounted on girder rails.

Luffing. Cranes With Variable Radius and Horizontal Track (Einziehkrane mit waagerechter Lastbahn), K. Ruediger. Foerdertechnik Frachtverkehr (Wittenberg), vol. 23, no. 9, Apr. 25, 1930, pp. 169–172, 10 figs. Different designs for obtaining luffability of jib cranes are described; influence of transmission members; method of calculation; efficiency calculation of different types.

CUPOLAS

Poumay. The Poumay Cupola, J. Cameron. Foundry Trade Jl. (Lond.), vol. 42, no. 716, May 8, 1930, pp. 338–340. Comparison of Poumay cupola with Greiner, Doherty, and Blakeney systems; inventor's theories; German view British steel founder's opinions; test data are give.

CUTTING TOOLS

Tungsten Carbide. Tungsten Carbide Tools, R. D. Prosser. Am. Soc. Steel Treating—Trans., vol. 17, no. 6, June 1930, pp. 749–764, 12 figs. Great interest aroused by development of cemented tungsten carbide at Krupp Works has resulted in considerable discussion of freak or trick results obtainable with these tools; author confines himself principally to description of some of results being obtained in everyday actual production work; definite and practical advice as to methods of application, grinding, and use which should be employed to take full advantage of remarkable properties of these tools.

D

DIE CASTING

Aluminum Alloys for. Designing for Aluminum Die Castings, D. B. Hobbs. Product Eng., vol. 1, no. 2, Feb. 1930, pp. 60–62, 6 figs. Die-casting process consists in forcing molten metal under considerable pressure into steel dies; main characteristics of die castings, their extreme accuracy, uniformity, and superior finish are result of not only method by which castings are made but also fine art developed in die construction; fact that aluminum alloys have higher melting point than lead, tin, and zinc alloys required development of special alloy steel dies; general description of casting process.

DIESEL-ELECTRIC POWER PLANTS

Costs. Report on Oil Engine Power Cost for 1929. Am. Soc. Mech. Engrs.—Advance paper, for Nat. Oil and Gas Power mtg., June 12–14, 1930, 21 pp. Report contains information covering 36 oil engine plants; tabular data covering lubricating oil, fuel oil, maintenance, and power cost.

Design. Diesel Power-Plant Layouts, E. W. Hammond. Am. Soc. Mech. Engrs.—Advance Paper, for Nat. Oil and Gas Power mtg., June 12–14, 1930, 7 pp. Information applies to Diesel power plants in general; consideration of plant site, plant equipment, buildings and foundations, plant layout, cooling-water system, fuel-oil system, starting air supply, and auxiliaries.

Quebec. Oldest Commercial Canadian Plant Add Large Stationary Diesel, G. H. Johnson. Elec. News (Toronto), vol. 39, no. 10, May 15, 1930, pp. 43–45, 3 figs. Pembroke Electric Light Co. have installed 1250 hp. Diesel engine direct connected to 60 cycle generator to take care of short daily peak during late autumn and early winter months; with generator efficiency of 92½ per cent and when operating at or near full load, engine will produce slightly in excess of 13 kw-hr. per Imperial gallon of fuel oil; fuel cost per killowatt hour will run approximately 0.73 cents.

DIESEL ENGINES

Compressorless. Compressorless-Double Acting Two-Cycle Diesel Engines of 12,000 hp. (Kompressorlose doppelwiekende Zweitakt-Dieselmotoren von 12,000 PS), W. Laudahn. V.D.I. Zeit. (Berlin), vol. 74, no. 15, Apr. 19, 1930, pp. 489–496, 19 figs. Description of operation, installation, and design of M.A.N. engines for Diesel-electric power plant; sketches show principal details.

Couplings. Vulcan Gearing and Hydraulic Couplings. Mar. Engr. and Motorship Bldr. (Lond.), vol. 53, no. 632, May 1930, pp. 175–179, 10 figs. Flexible hydraulic clutch or coupling, originated by inventions of H. Foettinger, has extended in scope of its application by patents granted to Gustav Bauer; principle of hydraulic coupling and some practical and special installations.

High-Speed. Development of High-Speed Heavy Oil Engines (La Réalisation des moteurs; Rapides à Huile Lourde), E. Marcotte. Arts et Metiers (Paris), vol. 83, no. 113, Feb. 1930, pp. 33–47, 10 figs. Discussion of factors controlling design and performance; thermodynamics of different cycles; injection; pulverized fuel turbulence; volumetric efficiency; carburation possibilities; notes on Junkers and M.A.N. designs. Bibliography.

The Design of High-Speed Heavy-Oil Engines, Ricardo. Engineering (Lond.), vol. 129, no. 3356, May 9, 1930, pp. 607–608. Editorial comment on paper read before Diesel Engine Users' Assn., previously indexed from Shipbldr., Apr. 1930; it may be doubted whether speeds much above present limit are practicable with engines of two conventional types; essential condition for high speed and details of Ricardo-Brotherhood type of engine; there appears to be no sound reason why engines of this airless-injection type should not successfully be applied to rail cars and even heavy commercial vehicles.

Ricardo. A Small Heavy-Oil Engine. Engineer (Lond.), vol. 149, no. 3879, May 16, 1930, p. 558, 3 figs. Engine which is capable of running on heavy oils, and is yet of such small size that it is adaptable to minor services has been produced by R. A. Lister and Co., designed by Ricardo; engines are being made in two ranges of sizes, one running at 600 other at 1000 r.p.m.

Testing. Results of Tests on Diesel Engines of Peak-Load Plant in Henningsdorf (Erge nisse von Versuchen an den Dieselmotoren des Spitzenkraftwerkes Hennigsdorf), W. Laudahn. V.D.I. Zeit. (Berlin), vol. 74, no. 18, May 3, 1930, pp. 570–575, 10 figs. Tests were carried out by Maschinenfabrik Augsburg-Nuernberg on compressorless double-acting two-stroke Diesel of 12,000 hp. built for Hennigsdorf Plant of Maerkischen Elektricitaetswerke; results are tabulated and critically analyzed.

Vibrations. Calculation of Torsional Vibrations in Diesel-Engine Installations (Zur Berechnung von Drehschwingungen bei Dieselmotorenanlagen), E. Goeller. V.D.I. Zeit. (Berlin), vol. 74, no. 16, Apr. 19, 1930, pp. 497–498, 6 figs. Development of two simplified formulas for calculating frequencies of systems, "engine—single mass" and "engine—two single masses;" graphs show relations of variables; numerical example.

E

ECONOMIZERS

Combined Air Heaters and. The "Supermiser"—A Combined Air-Heater and Economizer, T. B. Morley. Instn. Mech. Engrs.—Proc. (Lond.), no. 5, Dec. 1929, pp. 1043–1044. Details of apparatus introduced three years ago designed for combined air heating and feedwater heating.

Value of. The Economiser in Boiler Installations, G. E. Tansley. Iron and Coal Trades Rev. (Lond.), vol. 120, no. 3244, May 2, 1930, p. 721. Value of economizer as investment; tabular comparison of ordinary investment of 2000 pounds sterling and investment of same amount in steam economizer; boiler outlet-gas temperatures and gas velocities; economizer in relation to boiler pressure. Abstract of paper read before North of England Inst. of Min. and Mech. Engrs.

ELECTRIC FURNACES

Arc. Industrial Electric Heating, N. R. Stansel. Gen. Elec. Rev., vol. 33, no. 5, May 1930, pp. 316–322, 14 figs. Characteristic curves of furnace circuit; diagrams of connections and typical three-phase transformer design; characteristic curves of standard reactors.

Induction. The Ajax-Wyatt or Vertical Ring Induction Furnace as Applied to Melting Non-Ferrous Metals, W. Adam, Jr. Am. Electrochem. Soc.—Advance Paper no. 57–14, for mtg. May 28–31, 1930 pp. 143–164, 6 figs. Specifications for ideal electric melting furnace and operating data are presented to show that vertical-ring induction furnace more nearly meets these specifications than any other type; with this furnace thermal efficiencies as high as 85 per cent have been obtained; power input of vertical-ring furnaces varies from 45 to 150 kw. and pouring capacity from 400 to 2200 lb.

Heat-Treating. Electric and Fuel Costs for Four Heat-Treating Installations, W. S. Scott. Elec. World, vol. 95, no. 20, May 17, 1930, pp. 996–997. Comparative heat-treating costs for hardening and tempering of axes, automobile axles, shovels, and hardening of ball bearing races.

Melting. Electric Melting Improves Quality and Cuts Cost. Elec. World, vol. 95, no. 19, May 10, 1930, pp. 948–949, 1 fig. First vertical-ring induction furnace for melting nickel-silver in Naugatuck Valley went into service year ago; results obtained have been so satisfactory as to improved quality of alloy and melting costs that four furnaces are now in operation and five more have been purchased; lining life has increased from 400 heats to more than 800 heats, or about 500,000 lb. per lining; on this basis cost for lining is $1.40 per ton and is not likely $2 per ton of metal poured.

ELECTRIC GENERATORS

Shaft Straightening. Straightening a 15-Ton Shaft Without Shop Facilities, G. E. Decker and C. G. Heckman. Elec. West, vol. 64, no. 5, May 1, 1930, pp. 240–242, 4 figs. Field methods and equipment effectively reduce 0.021-in. curvature in 35-ft. vertical generator shaft; problem arose when 28,000-kvs. vertical unit at Big Creek No. 3 hydro-electric generating plant of Southern California Edison Co. developed vibration which requires its removal from service.

ELECTRIC WELDING

Flash Welding Machines. New Heavy-Duty Flash Welding Machines. AEG Progress (Berlin), vol. 6, no. 3, Mar. 1930, pp. 98–100, 3 figs. Invention about 15 years ago of flash butt-welding process opened way to welding of objects of fairly large cross-sections economically by agency of electricity; from this time onward, electric process commenced to force forge-welding method entirely into background; flash butt-welding machinery and table of results of strength testing.

ENGINEERING RESEARCH

Technique and. The Influence of Technique on Research, F. A. Freeth. Engineering (Lond.), vol. 129, no. 3357, May 16, 1930, pp. 640–641; see also Engineer (Lond.), vol. 149, no. 3879, May 16, 1930, pp. 541–542. Number of maxims are laid down which have been means of stimulating discovery in past; examination of importance of technique to those engaged in study of metals. Abstract of paper read before Inst. of Metals.

F

FLOW IN PIPES

Natural Gas. Determination of Coefficient of Friction in Long-Distance Gas Pipe Lines (Zur Bestimmung der Reibungszahl in Ferngasleitungen), E. Guman. Petroleum (Berlin), vol. 26, no. 13, Mar. 26, 1930, pp. 396–401, 3 figs. Investigations were confined to limited field of Reynold coefficient and showed no change with regard to pipe diameter and viscosity of flowing fluid; therefore no decided conclusions can be drawn from results, but necessity for further study of existing gas lines has been demonstrated; general formulas cannot be applied to turbulent flow in commercial pipe lines.

FLOW OF WATER

Measurement. Comparative Water-Discharge Measurements of the Walchensee Hydro-electric Plants (Vergleichs-Wassermessungen am Walchenseewerk), O. Kirschmer. V.D.I. Zeit. (Berlin), vol. 74, no. 17, Apr. 26, 1930, pp. 521–528, 19 figs. Report on results of comparative determination of discharge of penstock, 2.25 m. in diameter, by means of following methods and instruments: (1) Allen salt-velocity method, (2) Ott current meter, (3) Pitot tube of British make, and (4) the Gibson time-pressure method; discharge ranged from 2.5 to 8.2 cu. m. per sec.; results show considerable discrepancies and indicate reliability of current meters of propeller type.

FORGE SHOPS

Efficient Layout. Forge Shop Design Results in Efficient Operation, A. H. Allen. Iron Trade Rev., vol. 86, no. 20, May 15, 1930, pp. 47–50 and 57, 8 figs. Description of forge-shop layout and operation at plant of Lefere Forge & Machine Co., Jackson, Mich., specializing in hub forgings, ring gear blanks and other round-type forgings ranging in weight from 7 to 50 pounds; floor plan of main forge building is given.

FORGINGS

Steel. Snow Flakes in Alloy Steel Forgings, H. H. Ashdown. Iron Age, vol. 125, no. 19, May 8, 1930, pp. 1380–1381 and 1429, 3 figs. Description of "snow flake" phenomenon occurring mostly in nickel-chrome alloys, including those containing molybdenum and occasionally in tool-steel forgings in large section; origin is in ingot and mass action ultimate cause; heat treatment will not cure it.

FORMING MACHINES

Rotary. Rotary Forming, C. V. Lundeen. Am. Mach., vol. 72, no. 23, June 5, 1930, pp. 912–913, 4 figs. Description of design and operation of forming machines at Hawthorne plant of Western Electric Co.; in forming small parts of many designs, roller method has advantages over punch press; output from 18,000 to 43,200 per hour.

FUELS

Oil. See OIL FUEL.

Pulverized Coal. See PULVERIZED COAL.

G

GAGES

Taper. Checking a Taper Gauge. Machy. (Lond.), vol. 36, no. 920, May 29, 1930, p. 263, 2 figs. Description of method of checking angle and diameter of tapered disks; master taper gage with setting disks in place for checking working gages of male bevel-side taper type.

GALVANIZING

Hot. Bending Resistance of Hot Sheet Galvanizing (Biegefaehigkeit von Zink-Ueberzuegen), H. Bablik. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 5, May 1930, pp. 171–173, 10 figs. This process is assurance against corrosion only when coating is non-porous and when it does not break under bending stress; based on tests, author seeks to show that, it is not thickness of whole coating, but presence or thickness of iron-zinc layer that has influence on bending strength.

GAS ENGINES

Industrial Power Plants. The World's Biggest Gas Engines. Power, vol. 71, no. 19, May 13, 1930, pp. 736–738, 5 figs. Illinois Steel Company has added to gas-electric power plant two 6600-kw. units operating at 83 and 1/3 r.p.m. on blast furnace gas; physical dimensions and weights of gas-electric units are given.

GEARS

Burnishing. Three Master Gears Employed for Burnishing Pinions, C. H. Logue and C. O. Hersam. Automotive Industries, vol. 62, no. 19, May 10, 1930, pp. 722–723 and 737, 4 figs. Description of new process and machine built by Hersam and Sherwood, Philadelphia, Pa., in which pinion is constrained to definite relation with its apex point, but it is left free otherwise to move and find its own natural operating position. 60 to 90 pinions may be burnished; burnishing gears is expected to produce about 20,000 pinions before replacement.

Tooth Measurement. Constant Chord Gaging, W. A. J. Chapman. Am. Mach., vol. 72, no. 19, May 8, 1930, pp. 753–754, 3 figs. Constant-chord method differs from means of tooth measurement now in use solely in computations involved; substitution of constant for variable measurements of gears; since pitch and pressure angle are uniform in set or train of gears, whereas tooth number usually differs, measurements are greatly simplified by possibility of using constant dimensions for chordal length and depth.

GRINGING MACHINES

Gear. Grinding Helical Gears. Automobile Engr. (Lond.), vol. 20, no. 267, May 1930, pp. 184–185, 3 figs. Description of design and operation of a new machine particularly for automobile work built by Maag Gear Co., Ltd. Zurich; special feature is means for setting wheel heads over desired spiral angle with simple method of imparting additional rolling motion to gear to follow spiral.

Pneumatic. New Air Grinder for Use in Diemaking. Machy. (Lond.), vol. 36, no. 916, May 1, 1930, pp. 133–134, 5 figs. Description of design and use of tool built by Madison-Kipp Corp., in United States; capable of finishing irregularly curved surfaces in die-casting dies rapidly, and also for touching up such surfaces to correct any distortion produced in hardening; spindle speeds in excess of 40,000 r.p.m. obtainable for grinding wheels of very small sizes.

H

HEAT INSULATION

Laws, Application of. Heat Insulation, A. B. Winterbottom. Instn. Mech. Engr.—Prod. (Lond.), no. 5, Dec. 1929, pp. 1075–1086, 2 figs. Paper is devoted first to laws which govern flow of heat through insulation, and their application, and second, to survey of practical requirements, and of types of insulation developed to meet them.

HEAT TRANSMISSION

Surface. Surfaces Conductances as Affected by Air Velocity, Temperature, and Character of Surface, F. B. Rowley, A. B. Algren, and J. L. Blackshaw. Heat Piping and Air Conditioning, vol. 2, no. 6, June 1930, pp. 501–508, 22 figs. Investigation is part of cooperative research program between American Society of Heating and Ventilating Engineers and University of Minnesota; object is to determine effect of air velocity, temperature, and surface characteristics on heat transmission from surfaces; apparatus and method of testing; graphical representation of results for various types of surfaces. Presented before Am. Soc. of Heat and Vent Engrs.

HEATING AND VENTILATION

Buildings. Analysis of Heat Required for Buildings, X. Y. Zero. Blast Furnace and Steel Plant, vol. 18, no. 5, May 1930, pp. 797–801. Concise explanation of procedure for determining amount of heat which must be supplied to maintain building at desired temperature; estimating size of rooms, glass, doors, and pipes, carpenters rule; effect of paint; cost.

HOISTS

Brakes for. Centrifugal Brakes, A. W. Knight. Mech. World (Manchester), vol. 87, no. 2261, May 2, 1930, pp. 410–413, 3 figs. Design and calculation of new types of centrifugal brakes suitable for controlling lowering speeds of electric lifting gears; example of brake for 20-ton electric crab is followed through.

HOT-BLAST STOVES

Output Increase. Increasing the Output of Hot-Blast Stoves, J. Stoecker. Blast Furnace and Steel Plant, vol. 18, no. 5, May 1930, pp. 807–811 and 818, 8 figs. Results of experiments of Bochumer Verein with burners with propeller blowers; filler brick in checkerwork channels; layout of stoves; sketch of burner with air supply by means of jets around edge and burner with air supply by means of propeller blower with mixing tube and grid; effect of increase in heating surface; effect of filler bricks on waste-gas temperature; temperatures in different portions of checkerwork, before and after setting in filler bricks.

HYDRAULIC MACHINERY

Specific Speed. Specific Speed and Other Characteristics of Hydraulic Turbines, Centrifugal Pumps, Windmills, and Propellers as

Dimensionless Characteristics of Physics of Similitude (Die spezifischen Drehzahlen und die anderen Kenngroessen der Wasserturbinen, etc.), M. Weber. Schiffbau (Berlin), vol. 31, nos. 4 and 7, Feb. 19, 1930, pp. 73–80, Apr. 2, 156–161, 11 figs. Feb. 19: Principles governing specific speed; law of similitude as applied to derivation of dimensionless specific speed and other values. Apr. 2: Derivation of dimensionless characteristics and their relations to one another for this type of machinery and related flow problems.

I

INDUSTRIAL MANAGEMENT

Development of. The Development of the Art and Science and Philosophy of Management Since Taylor, H. P. Kendall. Soc. Indus. Engrs.—Bul., vol. 12, no. 4, Apr. 1930, pp. 4–9. Discussion of Taylor's principles of scientific management and application of inventory control, classification, methods study, scheduling, despatching, functional foremanship, cost accounting, and labor relations. Presented before Nat. Mgmt. Conference.

Inventory Control. Scheduling and Inventory Control, H. H. Flagg. Soc. Indus. Engrs.—Bul., vol. 12, no. 5, May 1930, pp. 3–12, 3 figs. Organization and methods for bulk stock control.

Labor, Philosophy of. Philosophy of Labor, J. O. Hopwood. Soc. Indus. Engrs.—Bul., vol. 12, no. 4, Apr. 1930, pp. 10–30, 1 fig. Factors affecting industrial organization; scope of functions of organizations; outline of grades of service in organized division of labor; typical form of organization and duties of each department; job analysis.

Large Plants. Management in a Large Plant—How to Obtain the Advantages of the Small Plant, A. B. Reynders. Am. Soc. Mech. Engrs.—Advance paper for mtg., June 9–12, 1930, 10 pp. Discussion of method by which advantages usually considered as resulting from small plant such as quick action, low production cost of small qualities, and close relationship of employee and employer may be obtained in large organizations.

Small Plants. Management of the Small Manufacturing Plant: Its Characteristics and Advantages, C. Field. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. June 9 to 12, 1930, 7 pp., 1 fig. Having ascertained that small plants greatly predominate, paper suggests two reasons; differences of plants in each of their activities are evaluated, and form composite figure having great influence on plants' chances of success; in discussing personnel, relative versatility is stressed, also advantage enjoyed by small plant in having higher incentive of part ownership for higher executives and immediate interrelation between effort and resulting bonuses among subordinate keymen. Bibliography.

INSPECTION

Optical Instruments for. Optical Aids to Engineering Inspection, A. F. C. Pollard. Inspection (Lond.), vol. 1, no. 2, Apr. 1930, pp. 79–102 and (discussion) pp. 103–113, 30 figs. Various types of optical instruments of use in inspection of manufactured products are described and their use is discussed.

INTERNAL-COMBUSTION ENGINES

Exhaust From. The Final State of a Gas Discharged From a Reservoir into a Space Under Constant Pressure, F. Modugno. Shipbldr. (Lond.), vol. 37, no. 238, Apr. 1930, pp. 475–476; see also Shipbldg. and Shipg. Rec. (Lond.), vol. 35, no. 16, Apr. 17, 1930, p. 501. Mathematical investigation based on laws of adiabatic expansion, of changes which occur in physical constants, such as pressure volume and temperature of gas discharged from one vessel into another, based on assumption that pressure in second vessel remains constant. Paper presented before Instn. Naval Architects, Apr. 1930.

Inertia Forces in. Inertia Forces in Reciprocating Engines, V. Jensen. Mar. Engr. and Motorship Bldr. (Lond.), vol. 53, no. 632, May 1930, pp. 189–190, 2 figs. For exact calculation of well-designed and proportioned connecting-rod bolts, it is necessary to determine inertia forces in reciprocating parts of engine; simple graphical method for calculation of these forces is explained.

Supercharging Compressors. New Compressor of High Output (Un nouveau compresseur volumétrique à grand debit), R. C. Faroux. Vie Automobile (Paris), vol. 26, no. 942, Mar. 25, 1930, pp. 117–119, 4 figs. Brief review of various systems of compressors; description of design and performance of P.Z. volumetric type; calculations for example of 20 liters output at 2000 r.p.m., weighing 22 kg.; with regard to supercharging advantages.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON ALLOYS

Specific Volume. Density of Some Liquid Alloys of Iron (Sur la densité de quelque alliages de fer à l'état liquide), C. Benedicks. Académie des Sciences—Comptes Rendus (Paris), vol. 19, no. 2, Jan. 13, 1930, pp. 114–116. Density of iron-carbon alloys at 1550 deg. and specific volumes with temperature coefficients at 1600 deg. are given; changes in specific volume upon addition of aluminum, chromium, manganese, nickel, phosphorus, silicon and tungsten are represented graphically.

IRON FOUNDRY PRACTICE

Duplexing. Duplexing With Cupola Makes High-Grade Iron Castings, H. E. Bromer. Iron Age, vol. 125, no. 19, May 8, 1930, pp. 1372–1376, 6 figs. Method of combining advantages of cupola and electric furnace used by Standard Foundry Co., Racine, Wis.; electric furnace is charged with molten cupola iron directly into rear of furnace; new process is more economical, gives higher impact values and uniform Brinell hardness.

L

LOCOMOTIVES

Alloy Steels for. Alloy Steels for Locomotive Construction, W. A. Johnson. Instn. Mech. Engrs.—Proc. (Lond.), no. 5, Dec. 1929, pp. 1087–1097, 1 fig. Alloy steels are particularly susceptible to heat treatment and wide range of properties is possible with given composition; drilling of forgings offers advantages; savings in weight are possible by more extensive adoption of steel of high tensile strength; it is shown that in case of locomotive considered, this amounts to 4 tons approximately, or 7 per cent of static weight of engine, and effect on dynamic hammer blow is shown to be more pronounced.

Diesel-Electric. Oil-Electric Locomotives Show Large Savings in Operating Costs, A. L. Foster. Nat. Petroleum News, vol. 22, no. 19, May 7, 1930, pp. 36–37, 1 fig. About 100 standard-gage Diesel-electric locomotives are in service or on order for railroads and industrial concerns in United States and Canada; used mainly in switching service; tabular data on operating costs; graph comparing tractive effort speed characteristics of Diesel-electric and steam locomotives.

Electric. Electric Locomotives for Main Line Traction, G. Bianchi. Int. Ry. Congress Assn.—Bul. (English Edition, Brussels), vol. 12, no. 5, May 1930, pp. 1410–1421. Classification of electric locomotives; types of transmission from motor to wheels; arrangement of trucks and bodies; wheel arrangements; lubrication; current collecting devices; lightning arresters; circuit breakers; transformers; traction motors; matters relating especially to locomotives for use in mountainous country; multiple-unit rail motors.

Switching and Transfer Locomotives, P. A. McGee. Ry. Elec. Engr., vol. 21, no. 5, May 1930, pp. 141–143, 4 figs. Illinois Central adopts locomotives with special weight transfer compensating features; nature of switching and transfer service; side elevation of locomotive showing structural details and principal dimensions; weight transfer compensation; locomotive characteristics; principal characteristics of locomotive units are given.

Manufacture, Heat Treatment in. The Heat Treatment of Locomotive Parts, W. A. Stanier. Instn. Mech. Engrs.—Proc. (Lond.), no. 5, Dec. 1929, pp. 1069–1073, 4 figs. At Swindon it is now practice to treat all steel stampings and forgings so that structure of each part is in best condition to resist strains and stresses to which it will be subjected in service; plant consists of vertical furnace with chamber 16 ft. 3 in. long and 2 ft. 2 in. diam., gas-fired; in addition there is horizontal three-chamber furnace; microphotographs are shown illustrating structure of axle steel in various conditions.

New Types. Locomotives of New Types; in Particular Turbine Locomotives and Internal Combustion Motor Locomotives, P. Koller. Int. Ry. Congress Assn.—Bul. (English Edition, Brussels), vol. 12, no. 5, May 1930, pp. 1383–1390. Report deals with construction, efficiency, use and repair of new types of locomotives, with particular reference to turbine and internal combustion.

Passenger. Great Northern Buys 4–8–4 Type Locomotives. Ry. Mech. Engr., vol. 104, no. 5, May 1930, pp. 249–250, and 260, 5 figs. Description of design features incorporated in Baldwin constant-resistance equalized engine truck; elevation and cross-sectional views of locomotive are given; cylinders 29 in. by 29 in. driving wheels 80 in.; steam pressure 225 lb. per sq. in.; maximum tractive force 58,300 lb.; total engine weight in working order 420,900 lb.; total engine wheelbase 47 ft. 9 in.

Testing. A 4–8–4 Type Demonstration Locomotive for Timken. Ry. Age, vol. 88, no. 21, May 24, 1930, pp. 1225–1230, 14 figs. Fifty-three specialty manufacturers cooperate in building locomotive with all axle journals equipped with roller bearings; description of engine-truck, trailing truck, and tender bearings; economies expected from Timken locomotive; cylinders 27 in. by 30 in.; driving wheels 53 in.; boiler pressure 250 lb. per sq. in.; maximum tractive force at starting 76,500 lb.; total engine weight in working order 417,400 lb.; total engine wheelbase 45 ft. 10 in.

Three-Cylinder. Examples of Recent Three-Cylinder Locomotives of Various Types. Ry. Mech. Engr., vol. 104, no. 5, May 1930, p. 261. Specifications concerning general dimensions, weights, and proportions of 16 various railroads.

LUBRICANTS

Progress in. Heavy Oils and Lubricants, W. Lee. Instn. of Petroleum Technologists—Jl. (Lond.), vol. 16, no. 81, Apr. 1930, pp. 266–280 and 2 supp. pp. Review of progress during 1928–1929; no new process introduced for production of heavy distillates or treatment to make them available as lubricant; increased use of Edeleanu liquid sulphur-dioxide process, applied to production of lubricants; production of heavy lubricants by polymerization; recovery of used oils; oxidation resistance; correlation between laboratory carbon tests and engine conditions; transformer oil tests. Bibliography.

LUBRICATION

Centralized System. Centralized Lubricating System Developed by Farfall. Automotive Industries, vol. 62, no. 19, May 10, 1930, pp. 734–735, 3 figs. Centralized high-pressure lubricating system, designed for all types of machinery and also applicable to automotive vehicles, made by Farfall Co. of Detroit; metering-type unit operates under pressure up to 2000 lb.; cross-section of automobile type of lubricator; model 400 pump assembly in section.

M

MACHINE TOOLS

Hydraulic Feeds. The Hydraulic Operation of Machine Tools. Engineer (Lond.), vol. 149, no. 3877, May 2, 1930, pp. 491–492. Editorial remarks on advantages of hydraulic transmission; that its possibilities are being realized by makers of machine tools was evident to all who inspected machinery exhibited at Leipzig Fair.

MACHINERY

Vibrations. Flexural Vibration of Machines (Biegungsschwingungen von Maschinen), J. Geiger. V.D.I. Zeit. (Berlin), vol. 74, no. 17, Apr. 26, 1930, pp. 542–544, 3 figs. Discussion of flexural vibrations of machine as a whole; computation of natural periods of vibration and of critical speeds, torsional vibration; bearing of vibration study upon design of machines.

Vibrations in Foundations From Theoretical and Experimental Point of View (Theoretische Betrachtungen und ausgefuehrte Versuche ueber Fundamentalschwingungen), H. Kayser and A. Troche. Beton u. Eisen (Berlin), vol. 24, no. 1, Jan. 5, 1930, pp. 15–18, 15 figs. Vibrations in foundations of turbines and other rotary machines are discussed from mathematical point of view and formulas are developed for calculating revolutions per minute which will produce marked resonance.

MALLEABLE IRON

Melting. Apply Continuous Process to Malleable, B. R. Mayne. Foundry, vol. 58, no. 10, May 15, 1930, pp. 61–64 and 90, 7 figs. Description of duplex melting system adopted at Malleable iron division, General Motors Corp., Saginaw, Mich.; data on use of soda ash as desulphurizer, life of refractories, metal charges; metal at cupola spout averages 2800 deg. while that at electric furnace spout is 2950 deg. fahr. Abstract of paper read before Am. Foundrymen's Assn., May 12–16.

MANGANESE STEEL

Properties. Study of the Pearlitic Manganese Steels, J. H. Hruska. Blast Furnace and Steel

Plant, vol. 18, no. 5, May 1930, pp. 802–806, 6 figs.; see also Heat Treating and Forging, vol. 16, no. 4, Apr. 1930, pp. 455–459, 6 figs. Composition and physical properties of various types of manganese steel; chart outlining advantages of pearlitic manganese steels; metallographic characteristics; illustrated by microphotographs; thermo-diffusion of carbon into surface of pearlitic manganese steel in carburizing; comparison of physical and chemical characteristics of pearlitic manganese steel with other alloy steels.

MATERIALS HANDLING

Coal. See STEAM POWER PLANTS, Coal Handling.

Industrial Plants. Handling of Heavy Materials. Iron Age, vol. 125, no. 21, May 22, 1930, pp. 1517–1520 and 1528, 5 figs. Versatility of materials-handling equipment and way in which one type doing certain class of work may feed into another type handling work somewhat differently; various methods used to handle materials in large manufacturing plant; adaptations which may be made within any given plant.

METALS

Calorizing. Heat Enduring Metals for Furnace Construction, B. J. Sayles. Fuels and Furnaces, vol. 8, no. 5, May 1930, pp. 699–701. Article deals mainly with calorizing process in which aluminum is driven into surface layer of another metal, usually mild steel, to form surface iron-aluminum alloy; this alloy is immune to oxidation up to maximum metal temperatures of 1650 deg. fahr.

Cold Rolling. Cold Roll Forming of Metals, D. A. Johnston. Metal Stampings, vol. 3, no. 5, May 1930, pp. 429–434, 6 figs. Design of rolls with reference to least distortion of metal, hardening and grinding, life and replacement, etc.

Cutting. Surface Conditions With Machining Operations, Especially With Turning (Das Oberflaechenaussehen bei der spanabhebenden Bearbeitung insbesondere beim Drehen), F. Rapatz. Arhiv. fuer das Eisenhuettenwesen (Duesseldorf), vol. 3, no. 11, May 1930, pp. 717–720, 17 figs. partly on supp. plates. Influence of cutting speed, strength, structure, wedge angle, etc., is discussed; reference is made to so-called Whitaker ring.

Drawing. Press Working and Forming of Metals—The Press Operations of Cold Forging, E. V. Crane. Metal Stampings, vol. 3, no. 5, May 1930, pp. 413–418, 8 figs. Discussion of plastic curves obtained in compression tests and typical cold forging operations such as sizing and rivet forming; cold forging of soft steel and copper.

Hardness and Flow Pressure. Hardness and Flow Pressure of Metal at Various Temperatures (Die Haerte und der Fliessdruck der Metalle bei verschiedenen Temperaturen), W. Schischokin. Zeit. fuer anorganische und Allgemeine Chemie (Leipzig), vol. 189, no. 2 and 3, Apr. 22, 1930, pp. 263–282, 8 figs. Report from Leningrad Polytechnic Institute on experimental study, including determination of Brinell hardness and flow pressure of several metals of low melting temperatures such as bismuth, lead, cadmium, zinc, tin, etc.; derivation of experimental formulas expressing variation of hardness and flow pressure with temperatures.

Internal Stresses. Internal Stresses Existing in Solids in the Absence of External Forces (Sur les tensions internes existent dans des corps solides en l'absence de forces extérieures). J. Seigle. Revue de l'Industrie Minérale (Paris), no. 222 and 223, Mar. 15, 1930, pp. 111–134 and Apr. 1, pp. 149–155, 51 figs. Modes of creating these mechanical and thermal stresses and examples of their effects; influence of internal stresses in iron and steel pipe subjected to internal pressure; evidences of internal forces; deformations and cracks; action of certain liquids; suppression and attenuation of internal forces.

Testing. Recent Progress in Tests for Automotive Materials, H. F. Moore. Am. Soc. Testing Matls.—Advance Paper for mtg., Mar. 19, 1930, 10 pp.. 2 figs. Viewpoint which author presents is that of testing engineer in university laboratory; tests for elastic strength; and creep strength; fracture; impact tests; tenderness of metals; understressing tests; ductility, and nondestructive tests; corrosion and strength.

Specimens for Torsion Tests of Metals, R. L. Templin and R. L. Moore. Am. Soc. Testing Matls.—Advance Paper No. 50, for mtg. June 23–27, 1930, 10 pp., 6 figs. Tests to determine influence of form and size of specimen upon results obtained in torsion tests; merits of hollow cylindrical specimens, having different ratios of diameter to wall thickness and length to diameter as well as those of hollow section were investigated; comparative results from hollow and solid specimens show little variation in values of modulus of elasticity in shear; data are given on influence of specimen proportions upon values of shearing yield point obtained from autographic diagrams.

Theory of. Recent Advances in the Theory of Metals, R. H. Fowler. Engineering (Lond.), vol. 129, no. 3356, May 9, 1930, pp. 595–597. Author concerns himself mainly with particular applications and results of quantum mechanics, without which no real progress could be made in theory of metals. Review of Kelvin lecture before Instn. Elec. Engrs., May 1, 1930.

METAL WORKING PLANTS

Production Control. Production Planning in Stamping Plants, J. W. Hallock. Metal Stampings, vol. 3, no. 5, May 1930, pp. 423–426 and 470. Economies of die, tool, jig, and fixture practice, factors to be considered and equations for solution of problems involving fixture costs.

[See also AIRPLANES; AUTOMOBILE MANUFACTURE.]

MOLYBDENUM STEEL

Manufacture of. Calcium Molybdate, Iron and Steel Making, T. W. Hardy. Blast Furnace and Steel Plant, vol. 18, no. 5, May 1930, pp. 784–788 and 795, 6 figs. Description of manufacture (Patent Kissock) and use of calcium molybdate; microphotographs of various molybdenum steels are given; typical analysis of commercial calcium molybdate; recoveries from calcium molybdate; steel melting practice; calcium molybdate in basic and acid open-hearth process; basic and acid electric process; bessemer and crucible steel process; cupola; ladle addition; air furnace; blast furnace; calcium molybdate in production of ferromolybdenum and in non-ferrous metallurgy.

MOTOR BUSES

Design. New Pickwick Duplex Coach Carries 53 Passengers. Bus Transportation, vol. 9, no. 5, May 1930, pp. 277–280, 7 figs. Day coach has 246-in. wheelbase; with full complement of passengers it weighs 25,000 lb.; measures 33 ft. long, 8 ft. wide and 9 ft. 10 in. high; novel heating system; longitudinal and plan views showing seating arrangement; six-cylinder Sterling "Petrel" engine; rated at 150 hp. at 1500 r.p.m.

MOTOR-TRUCK ENGINES

Design. Six-Cylinder Motor-Truck Engines, L. P. Kalb. Soc. Automotive Engrs.—Jl., vol. 26, no. 5, May 1930, pp. 601–606 and (discussion) 606–607, 3 figs. Aspects of truck-engine design with regard to higher road speeds; determination of maximum engine speed; power curves compared with horsepower required; curve of crankcase-oil temperature vs. engine speed, and viscosity curve of heavy engine oil vs. engine speed; engine-size determination; "speed-ratio" and "load factor" analyzed; oil-cooling problems.

N

NITRIDING

Use in Automobile Industry. Nitralloy in the Automotive Industry, H. G. Freeland. Soc. Automotive Engrs.—Jl., vol. 26, no. 5, May 1930, pp. 612–617. Special alloy, treated with nitrogen, is presented as having following ideal characteristics: lack of distortion during nitriding and permanence of contour thereafter, great hardness, high resistance to fatigue, and low coefficient of friction; constitution of metal and its properties before and after nitriding; procedures and precautions in heat treating, machining, and nitriding; methods for controlling hardness and depth of case and for local protection against nitriding, and time required for treating representative parts.

NON-FERROUS METALS

Cold Working. Cold Working of Lead, Tin, and Cadmium at Different Temperatures (Recherches sur l'écrouissage du plomb, de l'étain et du cadmium à différentes températures), A. Molnar. Académie des Sciences—Comptes Rendus (Paris), vol. 190, no. 9, Mar. 3, 1930, pp. 587–589. Cold working of lead to 25–50 per cent at minus 30 to minus 75 deg. produces permanent increase in hardness, while at minus 40 to plus 50 deg. hardness returns to its original value at rate which is greatest at higher temperatures; for tin and cadmium effect is permanent below minus 20 and 40 deg., and recovery is instantaneous at plus 50 and plus 25 deg.

O

OIL ENGINES

Automotive. Ignition by Compression or Spark for Automotive Heavy Oil Engine (Selbstzuendung oder Fremdzuendung im Fahrzeugschweroelmotor), A. E. Thiemann. Automobil-Rundschau (Berlin), vol. 32, no. 9, May 1, 1930, pp. 183–186, 4 figs. Comparison of various designs using compression ignition and electric ignition; sketches show details of Hesselman and Leroy engines; injection and combustion phenomena are discussed.

OIL FUEL

Choice of. Choice of Liquid Fuels (Die Auswahl der fluessigen Brennstoffe), E. W. Steinitz. Papier-Fabrikant (Berlin), vol. 28, no. 10, Mar. 9, 1930, pp. 154–158, 4 figs. Calorific value and specific gravity are unsuitable as criteria for evaluation of liquid fuels; volatility as shown by distillation curve is of greater value for this purpose; various types of motor fuels and Diesel oils, their distillation curves, anti-knocking properties, and comparative prices, are briefly discussed.

OPEN-HEARTH FURNACES

Italy. New Large Capacity Open-Hearth Furnaces of the "Terni" Company (Les nouveaux fours Martin à grande production de la Société "Terni"), G. B. Bruno. Aciers Spéciaux Métaux et Alliages (Paris), vol. 5, no. 55, Mar. 1930, pp. 99–106. Details and performance of furnace with normal capacity of 35 tons; its chief characteristics include special combustion chamber, means of controlling quality of flame and combustion, high temperature of recuperation, facilities for making all types of high-grade steel.

P

PHOTOELASTICITY

Phenomena Involved in. Phenomena Involved in Photoelasticity, R. V. Baud. Elec. Jl., vol. 27, no. 5, May 1930, pp. 303–305, 8 figs. Note on natural and polarized light; optical behavior of isotropic and anisotropic material; formation of isoclinics; formation of color fringes are given.

PIPE

Bending Stresses. A Study of Circumferential Bending of Pipes and Cylindrical Containers, R. J. Roark. Univ. of Wisconsin—Bul., no. 69, 1929, 48 pp., 2 figs. Results of partial analysis of circumferential bending moments produced in horizontal thin cylinders filled or partially filled with liquid and supported in different ways, and of bending moments produced in rings used to stiffen or support such cylinders.

PIPE, CAST-IRON

Centrifugal Casting. Machines Spin 10 Miles of Cast Pipe Daily, P. Dwyer. Foundry, vol. 58, no. 10, May 15, 1930, pp. 75–80, 11 figs. Brief synopsis of deLavaud process and detailed description of equipment, and of methods practiced at Birmingham centrifugal plant of United States Pipe and Foundry Co.; diagram of mold movement in production of each pipe; data on tolerances and physical properties of various sizes of pipe.

POWER GENERATION

Developments in. Power Production—Past, Present, and Future, F. C. Lea. Instn. Mech. Engrs.—Proc. (Lond.), no. 5, Dec. 1929, pp. 1045–1054. After brief review of historical development of prime movers, following questions are discussed: how it came about that before end of seventeenth century so little development was possible, and that from dawn of eighteenth century to present time such extraordinary progress has been made; what are possible limits of efficiency of present methods and whether there are sources of energy that have not yet been developed.

PRESSES

Multiple-Tool. Automatic Multiple Tool Presses (Presses automatiques à outils multiples), L. Lenouvel. Science et Industrie (Paris), vol. 14, no. 194, Mar. 1930, pp. 158–164, 9 figs. Various equipment developed by Hiltman and Lorenz (Hilo) Germany, is described in detail; economic features discussed.

PRESSURE VESSELS

Stresses in. Internal Pressure Stresses in Thin-Walled Vessels of Symmetrical Rotation Shapes (Ueber die Beanspruchung duennwandiger Gefaesse von rotationsymmetrischer Gestalt durch Innendruck), Z. Klembowski. Schweizerische Bauzeitung (Zurich), vol. 95, no. 20, May 17, 1930, pp. 257–259, 5 figs. Theoretical mathematical discussion leading to derivation of design formulas.

PULVERIZED COAL

Firing With. Pulverized-Coal Firing (Kohlenstaubfeuerung), A. Krenn. Montanistiche Rundschau (Berlin), vol. 22, nos. 5, 6, 7, and 8, Mar. 1, 1930, pp. 97–112, Mar. 16, pp. 125–132, Apr. 1, pp. 149–156, and Apr. 16, pp. 181–188, 25 figs. Systematic presentation of present status of pulverized-coal firing; physico-chemical and thermodynamic principles; technical details; types of pulverized-coal boilers, and equipment. Bibliography.

PUMPS

Centrifugal, Electrically Driven. Induction Motors for the Drive of Vertical Pumps. AEG Progress (Berlin), vol. 6, no. 3, Mar. 1930, pp. 94–97, 8 figs. Great flexibility of electric motor and especially its application as vertical motor has in recent years definitely promoted development of vertical-pattern centrifugal pump; typical pump installations are illustrated and described.

Feedwater. Centifugal Pumps for Feeding High-Pressure Boilers (Kreiselpumpen zum Speisen von Hochdruckkesseln), G. Weyland. V.D.I. Zeit. (Berlin), vol. 74, no. 15, Apr. 12, 1930, pp. 467–470, 14 figs. Detailed description and sketches of various arrangements for automatic fed-pump operation; experiences with pumps having labile and stable pressure output characteristics are illustrated by graphs; preheating and condensation features; notes on pumps made by Klein, Schnzlin & Becker: output 60 per hr., pressure 250 atmos. 6000 r.p.m.

Rotary Feed Pump With Combined Steam and Electric Drive. Engineering (Lond.), vol. 129, no. 3358, May 23, 1930, p. 683, 1 fig. Details of pump constructed by G. and J. Weir, Glasgow, for Schelle central station, Brussels; normally motor operates pump and turbine acts as standby, but latter also takes load automatically when motor cannot deal with it for any reason; pump has three stages; casing is of cast steel, gunmetal lined, with cast-steel end covers; discharge end covers contain hydraulic balancing arrangement for neutralizing end thrust.

Gas-Displacement. Two-Stroke Cycle Gas-Displacement Pump. Water and Water Eng. (Lond.), vol. 32, no. 377, May 20, 1930, pp. 218–220, 4 figs. Description of Christie large volume, low-head pump; pump consists of vertical stand pipe mounted on tee piece, one end of which leads to suction box fitted with sixteen 5-in. suction valves, submerged in tank; the other communicating with 60 ft. play pipe terminating in boiler; pump is capable of suction lift of 8 or 10 ft.; thermal efficiency of 14 per cent has been attained.

Submerged-Motor. Evolution of Submerged Motor Pumps (Die Entwicklung der Tauchpumpen), H. Sauveur. V.D.I. Zeit. (Berlin), vol. 74, no. 17, Apr. 26, 1930, pp. 530–532, 9 figs. Features of early and later types, with special reference to Garvenswerke, Arutuenoff; Siemens-Schuckertwerke, Reed Cooper, and other makes.

R

RAIL MOTOR CARS

Data on. On the Question of Rail Motor Cars (Subject XX for Discussion at the Eleventh Session of the International Railway Congress Association), Z. Zavadjil. Int. Railway Congress Assn.—Bul. (English Edition, Brussels), vol. 12, no. 2, Feb. 1930, pp. 443–490, 12 figs. Report covers data concerning cars of all countries of Europe, except France; types and principal data of rail motor-cars in service; table giving weights and power of rail motor-cars; organization of service, method of use; economic results of operation of rail motor-cars.

Lubrication. Proper Lubrication—The Life of a Motor Car, C. R. Knowles. Ry. Eng. and Maintenance, vol. 26, no. 6, June 1930, pp. 248–252, 5 figs. Practical suggestions regarding commonly neglected detail of operation that exerts marked effect on length of service; two-cycle engine; methods of mixing oil and gasoline; four-cycle engine.

RAILROAD TRAIN CONTROL

Cab Signaling. New Jersey Central Installs Cab Signaling on Single Track, Without Permissive Wayside Signals, F. W. Bender. Ry. Age, vol. 88, no. 20, May 17, 1930, pp. 1174–1176, 3 figs. Cab signaling on 11 mi. of single track between Matawan, New Jersey, and Atlantic Highlands has resulted in operating benefits and deferred second tracking; track and signal plan of territory equipped for cab signaling; description of signal system.

ROLLING MILLS

Aluminum, Furnaces for. Extremely Large Furnaces Used in Manufacture of Aluminum Structural Shapes. Fuels and Furnaces, vol. 8, no. 5, May 1930, pp. 637–638 and 646, 2 figs. Installation at the Massena, N. Y., plant of United States Aluminum Co., consists of four-coke-fired open-hearth furnaces for melting pig aluminum, electrically heated furnace with 14 pits for preheating ingots, oil-fired, conveyor-type, billet-heating furnace, and electric furnace for heat-treating structural shapes.

Electric Drive. Low-Pressure Turbo-Electric Drive for a 30-in. Cogging Mill. Iron and Coal Trades Rev. (Lond.), vol. 120, no. 3234, Feb. 21, 1930, pp. 315–316, 4 figs. Notes on electrification of mill at Hallside plant of Steel Company of Scotland, formerly driven by Galloway steam engine; flywheel generator set driven by steam turbine supplying power to totally enclosed forced-ventilated reversible motor of 5000 b.hp. capacity and capable of peak loads of 7500 b.hp.; motor is direct coupled to cogging mill, which reduces 3 ton ingots to 6 in. blooms, or smaller.

Modern Reversing Mill Drives, R. H. Wright. Iron and Steel Engr., vol. 7, no. 5, May 1930, pp. 210–217, 9 figs. Discussion of improvements and trends in reversing equipment based on experiments of Westinghouse El. and Mfg. Co.; torque calculation sketch of section through modern reversing motor showing path of ventilating air; graphs showing typical blooming mill power curve; tandem beam mill speed relations.

Lubrication. Steel Plant Lubrication Problems, W. A. James. Iron Age, vol. 125, no. 10, May 15, 1930, pp. 1455–1456, 1 fig. Description of modern lubrication methods; 30 per cent of total power shows up usefully in product while friction absorbs 49 per cent; improvements in Foll-Neck lubrication; table gives average lubrication cost for steel plants.

ROLLS

Sheet-Mill. Tin and Sheet-Mill Rolls, Their Treatment, Performance and Premature Failure in Service, E. R. Mort. Iron and Steel Inst.—Advance Paper, May 1930, 20 pp., 14 figs. Sheet plant to which data relate comprises 16 hot mills of single-stand type; there are no roughing stands, all bars being broken down and finished off on one pair of rolls; generally speaking, harder rolls expand more than mild ones; as body length increases, concavity decreases, converse being case with increase of diameters; pack lengths extend, so should concavity; lighter gage, less concavity required.

S

SAWMILLS

Electric Drive. Sawmill Uses 22,794 Hp., A. H. Onstad. Elec. World, vol. 95, no. 20, May 17, 1930, pp. 986–990, 4 figs. Change made in lumber industry in late years are pointed out; selling surplus power to utilities and latest ideas in sawmill power generation, field for synchronous and induction motors, importance of starting requirements and value of automatic starting and stopping are discussed; methods of instantaneously changing saw speeds and regulating feed to edgers; field for high-speed motors is also increasing; equipment used in felling trees is described; installation on Weyerhaeuser Timber Co. at Longview, Wash. is given as example.

SCREWS

Manufacture. Screws Made in Modern Plant, C. B. Phillips. Iron Age, vol. 125, no. 19, May 8, 1930, pp. 1377–1379, 5 figs. Description of manufacturing process and equipment at Rockford, Ill., plant of Elco Tool & Screw Corp., makers of wood screws, machine screws, cap, and lag screws, from small ones up to 1/2 in. di., and such finishes as bare polished, plated with cadmium, copper, brass, nickel or chromium, blued, oxidized, parkerized or raven black.

SEAPLANES

Passenger. The Do-X Flying Ship, C. Dorniker. Soc. of Automotive Engrs.—Jl., vol. 26, no. 5, May 1930, pp. 554–556 and 575, 28 figs. Scope of project and method of procedure in developing design; structural features; engine arrangement and mounting, hull construction and effect that increasing size has on ratio of weight and cost to capacity; comparison between weights and performance projected and those secured in actual trials; graph showing relation between loads and crusing radius; economic possibilities.

SHAFTING

Vibrations. Critical Vibrations in Shafting, M. Doucet. Shipbldr. (Lond.), vol. 37, no. 238, Apr. 1930, pp. 465–466, 2 figs. Simple methods for calculating critical speeds in line shafting and in turbine shaft; hypothesis is given that shaft may be divided into sections carrying at each extremity concentrated mass; system of such masses is dynamically equivalent to given system. Translated abstract of paper presented before Assocation Technique Maritime et Aéronautique.

SHEET METAL

Testing. Stamping Test for Metal Plates (Les essais d'emboutissage des toles), R. Cazaud. Aciers Spéciaux, Metaux et Alliages (Paris), vol. 5, no. 53, Jan. 1930, pp. 6–14, 19 figs. Description of test used for controlling annealing, and different types of testing machines employed.

SPRINGS

Helical. Further Research on Helical Springs of Round and Square Wire, A. M. Wahl. Am. Soc. Mech. Engrs.—Advance Paper, no. 24, for mtg. June 9 to 12, 1930, 8 pp., 21 figs. Proposed method of calculating stress in helical springs of square or rectangular wire is to use approximate formula, based on St. Venant's results for torsion of rectangular wire, and multiply by correction factor based on spring index; it is suggested that this new formula replace those commonly given in handbooks, which may lead to considerable error in certain cases. See Engineering Index, 1929, p. 1709.

STEAM-ELECTRIC POWER PLANTS

Design. Power Station Betterment. Nat. Elec. Light Assn.—Pub. No. 044, May 1930, 6 pp., 13 figs. Report indicates station betterments possible through modernization by addition of new equipment or remodeling of old; four examples of station betterment by minor capital expenditures are given, intended to show what can be done toward increasing capacity or improving economy with existing apparatus; substantial rebuilding; modernization of boiler house; modification of heat balance; increase in boiler capacity by use of larger stokers and water walls.

England. Extensions at Kingston-Upon-Thames. Elecn. (Lond.), vol. 104, no. 2706, Apr. 11, 1930, p. 457, 2 figs. Present extension comprises additions to boiler house; foundations, etc.; boiler, turbo-alternator, switchgear, and cables; foundations for boiler, owing to nature of ground, presented some difficulties; boiler plant is of Stirling five-drum type, with patent integral superheater and Green's tri-tube economizer; capable of producing 50,000 lb. of steam per hour with extremely large overload capacity; turbo alternator of Brush Ljungström type has output of 3000 kw. at steam pressure of 225 lb.

Long Beach, Calif. Edison Steam-Electric Generating Station Sets High Efficiency Mark for 1929. Elec. West, vol. 64, no. 3, Mar. 1, 1930, p. 133. Out of system total output of 3,162,988,-030 kw-hr. for 1929, Long Beach steam station of Southern California Edison Co. generated 1,309,-522,170 net kw-hr., 40 per cent of system output power was generated from natural-gas fuel, less than 1 per cent of steam output being from oil as fuel.

Long Beach Continues Its High Economy, F. G. Philo. Elec. World, vol. 95, no. 20, May 17, 1930, pp. 984–985, 1 fig. This summary together with information given in May 18, 1929, issue of same journal extends information given on operation of this 100,000-kw. single-shaft turbo-generator unit from time throttle was first opened up to end of year 1929. See Engineering Index, 1929, p. 1725.

Scotland. Extensions at the Portobello Power Station. Engineer (Lond.), vol. 149, no. 3878, May 9, 1930, pp. 524–526, 6 figs. In each of two new boiler houses, steam generating plant consists of 4-tri-drum units with integral superheaters, tri-drum economizers, and air heaters; four of boilers are designed for continuous output of 80,000 lb. per hr. and four for 90,000 lb. per hr.; two new turbo-alternator sets have each been designed for maximum continuous output of 31,250 kw. at 0.8 power factor and run at speed of 1500 r.p.m.; turbines are of three-cylinder type with double exhausts, and there are two separate condensers for each set.

Stand-by. San Francisco Steam Plant, H. K. Fox. Elec. Light and Power, vol. 8, no. 3, Mar. 1930, pp. 35–37 and 100–101, 5 figs. Description of 35,000-kw. steam plant designed for emergency standby service to protect city load; unit is to be kept to temperature and rolling at full speed at all times as synchronous condenser; under emergency throttle valve will automatically be opened in 1 1/2 sec.; pressure will drop from 400 to 235 and return again to 350 in 20 min.; details of construction and erection of equipment are given.

Standby Permits Instantaneous Load Pick-up. Elec. World, vol. 95, no. 16, Apr. 19, 1930, pp. 783–784, 1 fig. 35,000-kw. turbo-generator normally floated on line as synchronous condenser able to pick up full load instantly in case of system trouble; Great Western Power Company's new steam standby plant in San Francisco; liberal boiler capacity, extra large steam and hot

water storage facilities, arrangement to bypass steam into second stage of turbine, and many automatic features in connection with auxiliaries and house turbine makes this possible.

Standby Steam Plant Designed for Instantaneous Load Pick-Up, H. K. Fox and J. M. Renfrew. Elec. West, vol. 64, no. 3, Mar. 1, 1930, pp. 117–122, 5 figs. In San Francisco plant of Great Western Power Co. of California, 43,750-kva. generating unit is to run normally as synchronous condenser and to pick up full load instantaneously in system emergency; electrically driven auxiliary equipment operates from system through 2500-kva., 11.5/2.3-kv. station service transformer bank, but in case of emergency is thrown automatically upon 2500-kva. house turbine-generator unit; plant supplements other sources of power connected to Company's system.

STEAM ENGINES

High-Pressure. The Steam Engine as the High-Pressure Prime Mover, J. F. Ferguson. Power, vol. 71, no. 19, May 13, 1930, pp. 745–746. For industrial use, author foresees prime movers of reciprocating type, adapted to moderate, high, or extreme initial pressure.

Governors. Governor Gear for High-Speed Reciprocating Steam Engine. Engineering (Lond.), vol. 129, no. 3355, May 2, 1930, pp. 570–571, 6 figs. Account of construction and operating of governor; operation is such that sheave center is altered relatively to center of shaft when variation of load occurs; regulation of both valves simultaneously by governor enables receiver pressure to be maintained to practically uniform degree at all loads.

STEAM PIPE

Fittings for. Shut-Off Valves for Steam Power Plants (Absperrvorrichtungen fuer dampfkraftwerke), H. Schlicke. Waerme (Berlin), vol. 53, no. 19, May 10, 1930, pp. 350–352, 6 figs. Different types of steam shut-off valves, return traps, and safety cocks are described.

STEAM POWER PLANTS

Coal Handling in. Coal and Ash Handling. Nat. Elec. Light Assn.—Report, no. 036, Mar. 1930, 15 pp., 26 figs. Statements covering recent installations and improved equipment available; recent practice indicates trend toward ash removal by water slucing; slag-tap furnaces are being introduced for certain conditions; consideration is given to removal of cinders and fly ash from flue gases.

Design. Power Plant Development, C. F. Hirshfeld. Blast Furnace and Steel Plant, vol. 18, no. 5, May 1930, pp. 812–816, 9 figs. Changes in power-plant design and operation in last few years; graphs show increase in total steam temperatures, in physical size of boiler units, in steaming capacities of boiler units, and in main unit turbine sizes; thermal economy of plants operating on 50–60 per cent annual load factor; output per boiler unit 800,000 lb. thermal gains by regenerative feed heating; theoretical heat consumption per kw-hr. at different pressures and temperatures; efficiency at various temperatures of heated feedwater and with varying number of extraction points; high-pressure equipment.

High-Pressure. Modern Problems of High-Pressure Steam (Neuzeitliche Probleme der Hochdruckdampftechnik), S. Loeffler. Waerme (Berlin), vol. 53, no. 15, Apr. 12, 1930, pp. 281–284, 10 figs. Sankey diagram and layout of high-pressure steam plant with author's boiler are presented; influence of pump performance on efficiency; heat utilization at different pressures, live steam, and intermediate superheating temperatures; comparison of high-pressure steam plants of this type with and without economizers. This paper, which was contribution to Stodola Festschrift, represents last work of deceased author.

Pipe Lines. Pipe Lines for Steam Power Plans (Rohrleitungen fuer Dampfkraftwerke), E. Kaschny. Waerme (Berlin), vol. 53, no. 16, Apr. 19, 1930, pp. 297–303, 23 figs. Factors governing design of pipe lines; calculation of pipe; advantages and disadvantages of some flange fittings; calculation of screws; materials for packing; branches; heat expansion and heat-equalizing devices; calculation of steam and water pipe lines.

Pulverized-Coal-Fired. Experience Pooled in Pulverized Fuel Burning. Power House, vol. 24, no. 2, Feb. 1930, pp. 55–56. Summary of pulverized-fuel practice has been issued by National Electric Light Association in which personal investigation statements from users and statements from manufacturers are given; coal fineness, sampling methods; boiler operation; burner and furnace operation.

Textile Mills. Algonquin Printing Co. Rebuilds Power Plant, P. W. Swain. Textile World, vol. 77, no. 15, Apr. 12, 1930, pp. 2180–2181, 2 figs. Illustrated description of power equipment changeover at Algonquin Printing Co., Fall River, Mass.; Scotch boilers with superheaters; power units; list of principal new power equipment installed.

STEAM TURBINES

Testing. Consumption Tests of Turbines With Reheating of Feedwater; Flow of Hot Water Through Nozzle (Essais de consommation des turbines à réchauffage de l'eau d'alimentation), M. Hentsch. Science et Industrie (Paris), vol. 14, no. 192, Jan. 1930, pp. 4–6, 4 figs. Analysis of measurements and tests with standard nozzle placed in pipe system.

STEEL

Alloy. See ALLOY STEELS.

Chromium-Manganese. See CHROMIUM-MANGANESE STEEL.

Copper. See COPPER STEEL.

Manganese. See MANGANESE STEEL.

Molybdenum. See MOLYBDENUM STEEL.

STEEL CASTINGS

Temperature Effect. The Effect of Low Temperatures Upon the Impact Resistance of Steel Castings, R. W. Moffatt. Can. Jl. of Research (Ottawa), vol. 2, no. 5, May 1930, pp. 327–340, 26 figs. partly on supp. plates. Investigation deals with steel castings and forgings; low, medium, and high carbon-steel castings and alloys of vanadium, nickel, and vanadium-nickel steel castings were examined; temperatures varied from room temperatures to temperatures well below zero deg. fahr.; impact resistance of metals decreased for temperatures below freezing point; by proper heat treatment of steel castings impact resistance at 40 deg. may be brought over 300 per cent higher than that of untreated metal at that temperature.

STEEL

Heat Treatment, Electric. Electric Heating of Metals (Ein Erhtzungsverfahren fuer Metalle auf elektrischem. Wege), F. Staeblein. Stahl u. Eisen (Duesseldorf), vol. 50, no. 9, Feb. 27, 1930, pp. 263–264, 1 fig.; see also translated abstract in Metallurgist (Supp. to Engineer, Lond.), Apr. 25, 1930, p. 61. Electric method of heating metal pieces under water was described by inventor of process, P. Hoho, in Elec. Rev., Feb. 1 and 8, 1929; his description of phenomena and effects produced has been confirmed by trials made at Kaiser Wilhelm Institut fuer Eisenforschung at Duesseldorf and also by author; diagram is shown illustrating application of method to hardening of head of steel rail.

STOKERS

Coke-Fired. A New Type of Grate for Small Fuel. Eng. and Boiler House Rev. (Lond.), vol. 43, no. 11, May 1930, pp. 675–678, 4 figs. So-called "mushroom-valve" made by Kohlenveredlung A. G., Berlin, specially designed for combustion of coke derived from brown coal by low-temperature carbonization and for combustion of other small fuel, developed by Geissen in conjunction with K. and T. Moeller, Brackwede; grate consists of number of perforated, rectangular plates, each perforation being provided with mushroom headed spindle so shaped that it allows passage of air while preventing escape of fuel.

T

TEXTILE MACHINERY

Gearing. Improving Gear Performance on Textile Machinery, P. S. Huntley. Textile World, vol. 77, no. 18, May 3, 1930, pp. 96–97, 4 figs. Discussion of good gear performance which requires exact alignment of studs or shafts that carry gears, true running of gear on stud or shaft, correct meshing of gears, and intelligent oiling; gears with cast teeth; types of oilers.

TEXTILE MILLS

Electric Motors for. Style of Enclosure for Textile Motors. AEG Progress (Berlin), vol. 6, no. 3, Mar. 1930, pp. 52–54, 8 figs. In textile industry large quantities of dust and fluff in atmosphere render service conditions extremely unfavorable; various methods of protecting motors are described and illustrated.

Lighting. Elsol-Lighting in the Textile Industry. AEG Progress (Berlin), vol. 6, no. 3, Mar. 1930, pp. 82–89, 20 figs. Elsol workshop lighting units for direct lighting; Elsol diffusors for indirect, semi-indirect, and direct lighting; Elsol diffusors for semi-indirect lighting; typical lighting installations; luminous intensity required for various rooms are given in table.

Waste-Heat Utilization. Heating Water for Process Work in Textile Mills, C. L. Hubbard. Textile World, vol. 77, no. 14, Apr. 5, 1930, pp. 2024–2027 and 2075, 13 figs. Discussion of economy of using exhaust steam for heating waters in textile mills; description of various types of heaters for heating large quantities of water and proper equipment layout to insure best results; explanation of methods; whereby waste heat of Diesel engines may be utilized for heating water for textile processes.

Waste Heat Economy in Textile Mills. AEG Progress (Berlin), vol. 6, no. 3, Mar. 1930, pp. 49–51, 5 figs. General notes on study of process and consequent development of equipment by A.E.G. advantageous for steam consumption, for producing moist atmosphere, for heating and for drying plants of weaving, bleaching, printing, dyeing, and dressing mills.

TOLERANCES

Hole Centers. Limiting Dimensions on Centres of Components and Gauges, L. E. Bunnett. Machy. (Lond.), vol. 36, no. 914, Apr. 17, 1930, pp. 87–88, 2 figs. On dimensions of hole centers number of points arise which call for careful consideration and calculation before deciding upon tolerances; by examination of actual example author shows that clearance holes may be too small if certain limits are used and further that gaging may be made practically impossible.

Holes. Tolerances and Tools, D. W. Ovaitt. Am. Mach., vol. 72, no. 23, June 5, 1930, pp. 903–905, 1 fig. Description of practical system of cylindrical hole limits based on manufacturing considerations; tables give cylindrical hole tolerances and dimensions of straight shank machine reamers.

TRACTORS

Agricultural. Standardization of the Power Take-Off for Farm Tractors, W. L. Zink. Agric. Eng., vol. 11, no. 2, Feb. 1930, pp. 75–79, 10 figs. Discussion of practicability of power take-off method of utilizing tractor engine power; specifications of power take-offs of tractors; type and size of power take-off shaft ending; power take-off speed and direction of rotation; shaft location. Paper presented before Am. Soc. Agric. Engrs.

TURBO-GENERATORS

Bedplates. Heavy, Cast-Iron Bedplates Do Not Assure Alignment, J. A. MacMurchy. Elec. Jl., vol. 27, no. 5, May 1930, pp. 271–273 and 291, 5 figs. Bedplates can be made from structural steel shapes for about same cost as cast iron and without expense of patterns and their storage.

W

WELDS

Testing. Fatigue Tests of Fillet Welds, R. E. Petersen and C. H. Jennings. Am. Soc. Testing Matls.—Advance Paper No. 40, for mtg. June 23–27, 1930, 10 pp., 8 figs. Test data covering effects of machining, spacing and size of weld; tests were all made on rotating cantilever specimens 1 in. in diam.; it was found that fatigue strength of fillet weld could not be increased appreciably by machining radius at base of weld; spacing was found to reduce fatigue strength considerably.

WOOD

Water Penetration. The Penetration of Water Vapor Into Wood, L. M. Pidgeon and O. Maass. Can. Jl. of Research (Ottawa), vol. 2, no. 5, May 1930, pp. 318–326, 3 figs. Rate of diffusion of water vapor through wood has been studied through comparison of time taken for samples of various thickness to become saturated; comparative numerical values have been obtained of rate of diffusion of water vapor through spruce and pine in various directions through heartwood and sapwood, and through samples of different lengths.

WOOD PRESERVATION PLANTS

Inventory Control. Watchdog of the Stockpile, W. P. Conyers, Jr. Factory and Indus. Mgmt., vol. 79, no. 5, May 1930, pp. 1057–1060, 6 figs. Perpetual inventory control system of Taylor-Colquitt Co., Spartanburg S. C., which takes less than full time of one clerk in wood preserving plant with annual production of more than 50,000,000 board feet of lumber.

WROUGHT IRON

Puddling. Making Wrought Iron Mechanically in 700-lb. Balls. Iron Age, vol. 125, no. 25, June 19, 1930, pp. 1814–1817, 5 figs. Description of puddling and equipment at plant of Wrought Iron Co. of America at Lebanon, Pa.; notes on rolling mills and bolt factories.

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IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 52 | August, 1930, Section Two | Number 8

What It's All About

IN SUMMER, active men find so many demands on their time—both professional and recreational—that their reading is likely to suffer. But they like to know what is in the technical journals, and this supplement to MECHANICAL ENGINEERING is designed to tell them "What It's All About."

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Politics and Economics

WITH the country's most eminent engineer serving as its president, and with many other engineers engaging in civic service in increasing number, the economic and political consequences of engineering practices become important. Aside from telling lucidly and in an interesting manner the story of the Dawes and Young plans for international settlements, the Charter Day address by Owen D. Young, delivered at the University of California and printed in the August issue of MECHANICAL ENGINEERING, indicates some of the conflicts in which men trained in such factual methods as those employed by economists and engineers find themselves when dealing with politicians.

High-Pressure Steam

A SHORT paper on "The Economics of High-Pressure Steam," presented by Geo. A. Orrok at the Second World Power Conference, and published in the August issue of MECHANICAL ENGINEERING, concludes with the following six points:

"1 Thermal economies gained by raising pressures are considerable in the lower ranges, but above 1500–1600 lb. become of lesser value.

"2 Thermal economies gained by increasing temperatures have much smaller values which maintain throughout the range investigated.

"3 The installation costs per kilowatt, while now somewhat higher for the higher pressures, are apparently equalizing as the machinery is being standardized.

"4 There is less variation between operation and maintenance costs of high- and low-pressure stations than between the same costs in individual low-pressure stations.

"5 Commercial economies include both operation and fixed charges, and commercial savings follow high use factors.

"6 The cheapest cost of power predicates high use factor, low fuel cost, and high pressure and temperature."

Machining Large Steel Drums

WHEN American engineers designed boilers for very high pressures—1400 lb. per sq. in.—they adhered to the drum type, but found it necessary to increase the thickness of the shell to a point where riveted plates could no longer be used. John E. Strachan, in an article entitled "Machining Seamless Forged Steel Drums for High-Pressure Work," in the August issue of MECHANICAL ENGINEERING, describes the processes involved in the manufacture of a boiler drum having an outside diameter of 60 in., an inside diameter of 51 in., a total length of 41 ft., 9 in., and a weight of 106,920 lb. The drum was hollow-forged from a steel ingot 82 in. in diameter, 164 in. long, and weighing 301,000 lb.

More About Steam Turbines

PROF. A. G. CHRISTIE'S paper on steam turbines, presented at the Second World Power Conference at Berlin in June, is concluded in the August issue of MECHANICAL ENGINEERING. The second instalment contains an analysis of rating for a turbine casing. It also discusses small turbines, i.e., those of less than 5000 kw. capacity. Such turbines are used for auxiliary drive and for industrial plants.

Professor Christie's conclusions are as follows:

"The engineer's ideal in every case would be the selection of the one best turbine for every job. However, as indicated, such independent variables as size, use factor, fuel cost, first cost, and fixed charges, produce a large number of combinations of which several may be equally efficient when measured by the standard of 'total cost per kilowatt-hour of output.' This leads to differences in opinions and in practice and to variations in design. Meanwhile the field of application of steam turbines in both industrial-power and central-station services has steadily increased.

"It is not within the province of an engineer to predict future developments in power generation. However, the place for steam turbines in the generation of power seems to be steadily expanding. The more extended use of water power will necessitate the construction of auxiliary steam-turbine plants for operation in low-water periods and during dry seasons in order to utilize the available water most economically. In some cases water power, depending largely or wholly upon pondage, carries the peak loads, while steam-turbine plants furnish the long-hour service loads.

"Looking into the immediate future, there does not appear to be any new machine or process that is now under development for producing power which may be expected to displace the steam turbine. While one cannot foretell when new sources of energy may be discovered, information now at hand indicates that during coming years one must continue to use steam turbines to supply the major power demands of the world."

What's New in Aeronautics

PROF. ALEXANDER KLEMIN of the Daniel Guggenheim School of Aeronautics, New York University,

has prepared a report on the N.A.C.A. Conference at Langley Field, at which the aeronautical experts of the country had an opportunity to learn about the Committee's work and to discuss the problems which seem most important to aeronautical engineers at the present time. The report tells of the 20-ft. propeller-research tunnel, of the refrigerated wind tunnel, of the work of aerodynamic, propeller, and engine research, and summarizes briefly the discussion of possible research problems.

Lubrication Research

FOR a brief survey of the research which has been done in the important field of lubrication, the synopsis of the address by Mayo D. Hersey before the Detroit Section of the A.S.M.E., published in the August issue of MECHANICAL ENGINEERING, provides excellent material. It also contains an important bibliography.

Permanent-Mold Casting

MASS production of castings in permanent molds of cast iron has made it possible to do away with many of the costly and time-consuming tasks in a foundry. A machine for making castings of this type is described in the August issue of MECHANICAL ENGINEERING. In the Holley machine described there are twelve molds arranged on a turntable so that twelve castings are completed in one revolution of the turntable. The time required for a revolution depends on the size of the casting and is from $1^1/_2$ to 4 min. With small castings, several may be made in a single mold, thus increasing the capacity of the machine. The accompanying illustration shows the kinds of castings that may be made in the permanent-mold machine.

Aeronautical Materials

AT A RECENT meeting of the American Society for Testing Materials there was presented an excellent and frank discussion of aeronautical materials. The principal features of this discussion of interest to mechanical engineers are summarized in the August issue of MECHANICAL ENGINEERING.

Tungsten Carbide

IN THE July issue of MECHANICAL ENGINEERING, two of the papers on tungsten-carbide cutting tools read at the Semi-Annual Meeting of the A.S.M.E. were published. In the August issue will be found the Progress Report No. 2 of the Subcommittee on Tungsten-Carbide Cutting Materials, also presented at this meeting. The report concludes as follows:

"Tungsten-carbide tools have been on the market for about a year and a half, but their use on production work is very limited as yet. A year ago it was thought that the development of tungsten carbide with respect to material and tools would progress much more rapidly than improvements would be made in adapting machines to the use of this material. This does not seem to have been the case. Improvements in the quality of the material, and in the efficiency of the tools and machines, seem to be advancing together. The improvement of the machines, however, is a large undertaking, and we may expect important changes in design for some time to come. A large amount of evidence proves that for certain classes of work, tungsten-carbide tools can be used with considerable economy on old-style machines provided they are in good condition. These tools are being experimented with by a large number of machine-tool users in an endeavor to adapt them to present machine set-ups. We need not expect that the transition from the use of old-style machine equipment to the use of highly developed machine equipment due to the more general adoption of tungsten-carbide tools will be unduly rapid.

"The technique involved in the use of tungsten-carbide tools is quite different from that involved in the use of steel tools, and it will take some time to train shop people in the proper methods of handling, grinding, and setting up tools and machines. The development of this technique is rather expensive, but if the initial applications are made where appreciable saving can be effected, the cost of further and more difficult applications will be compensated for, at least to some extent. A wide demand for machine equipment from which maximum efficiencies can be obtained with the use of tungsten-carbide tools will undoubtedly develop with experience gained from successful and efficient applications on present equipment."

TYPICAL CASTINGS MADE IN A PERMANENT-MOLD CASTING MACHINE